WILSON ORNITHOLOGICAL CLUB

The American Midland Naturalist

Devoted to Natural History, Primarily that of the Prairie States

Founded by J. A. Nieuwland, C. S. C.

Contents

Vol. 22 NOVEMBER, 1939 No. 3

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The following numbers are out of print: vol. 1, (1, 5, 11, 12); vol. 2, (1-3, 8-10); vol. 3, (1-3, 5-12) index, title page; vol. 4, (1-7, 12) index, title page; vol. 5, (6-8); vol. 6, (5, 8, 9, 12) index, title page; vol. 7, (6); vol. 9, (9, 10); vol. 10, (11-12) index, title page; vol. 11, (1); vol. 12, (12); vol. 14 (1,5). All others available, 30 cents per copy. Complete volumes: $3.00; volumes 7, 13, and 14, $1.50 each; vol. 15, $2.00, single issues, 35 cents; vol. 16, $3.00, single issues, 50 cents; vol. 17, $4.50, part 1, $2.00, nos. 2-6, 50 cents each; vol. 18, $3.00, single issues 50 cents; vol. 19, $2.50, vol. 20, $2.50, single issues, $1.00; vol. 21, $2.50, single issues, $1.00.

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For citation use this abbreviation: *Amer. Midl. Nat.*

Entered as second-class matter at Notre Dame, Indiana. Acceptance for mailing at special rate of postage provided for in section 1103, Act of October 3, 1917, authorized on July 3, 1918.

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Published Bi-Monthly by The University of Notre Dame, Notre Dame, Indiana

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A Revision of the North American Species of Descurainia

LeRoy E. Detling

This investigation has been undertaken with the feeling that a taxonomic revision of a genus ought to reach farther than to a mere enumeration of the species and other taxonomic units, along with the usual keys and descriptions, geographic ranges and citations of specimens. Species are dynamic entities, capable of infinite genetic variation, of wide migrations and of adaptation to new and changing environments. Unless a taxonomic investigation is based upon the whole biology of the group of organisms under consideration, and attempts to interpret present data with a view to understanding the past history and the possible future development of the group it falls short of its highest purpose. Many of the data in such an investigation will necessarily be gained from direct observation of the behavior of populations under natural conditions, but I feel that we should welcome also as an invaluable tool any work of an experimental nature which may test the relative importance of the various factors making a population what it is.

The conclusions expressed in the present revision have been reached largely through herbarium studies and through field observations made throughout the Rocky Mountain and Pacific Coast regions on the distribution, local variations and ecological requirements of the species. The herbarium studies have been based upon specimens loaned, and in a few cases upon photographs provided, by a number of institutions and individuals in the United States, Canada and Europe. A list of these follows, with the abbreviations used in the citation of their specimens in this paper:

(BM)—British Museum (Natural History)
(C)—University of California, Berkeley
(Col)—University of Colorado
(DS)—Dudley Herbarium, Stanford University
(GH)—Gray Herbarium, Harvard University
(ISB)—University of Idaho, Southern Branch
(K)—Royal Botanic Gardens, Kew, England
(Mo) Missouri Botanical Garden
(McG)—McGill University
(NE)—New England Botanical Club
(NMC)—New Mexico State College
(NY)—New York Botanical Garden
(Or)—University of Oregon
(OSC)—Oregon State Agricultural College
(PAS)—Academy of Natural Sciences, Philadelphia
(Par)—Museum National d'Histoire Naturelle, Paris

(Po)—Pomona College
(RM)—Rocky Mountain Herbarium, University of Wyoming
(S)—University of Saskatchewan
(SCW)—State College of Washington
(Th)—Mr. J. William Thompson, Seattle
(T)—University of Toronto
(US)—United States National Herbarium
(W)—Willamette University

Although extensive experimental work could not be carried on in addition to the distributional studies, nevertheless in the course of the field work seeds were collected of most of the forms encountered, and these were later grown at Eugene under controlled conditions of moisture and light to determine the effect of these two factors upon the appearance of the plants. Some of the results of these experimental cultures will be given later in this discussion. Due to the short time available for these I can hardly claim that they have proved conclusively the points I shall present. However, I feel that the results do help to substantiate some of the conclusions reached through other means.

Earlier American botanists included our Descurainias in the genus *Sisymbrium*, it being only in more recent years that some systematists have held that the presence of branched pubescence in this group of species, combined with certain other rather distinctive characters, warrants its being considered a separate genus.

The earliest reference in scientific literature to any of the native North American species of *Descurainia* is in Walter's "Flora Caroliniana" (1788), in which the author described *D. pinnata* (as *Erysimum pinnatum*). The first extensive treatment of our species in a flora was that by Torrey and Gray in the "Flora of North America" in 1838. With the exception of the introduced *Sisymbrium Sophia* and the arctic and subarctic *S. sophioides*, these authors listed and described all of the American forms known to them as six varieties of Nuttall's *Sisymbrium canescens*. Later Fournier made an extensive study of the genus *Sisymbrium* (sensu lato), incorporating the results of his work in his "Recherches sur les Cruciferes," published in 1865. This monograph is of particular interest to us, owing to a number of new species described from Mexican collections. The Pacific Coast species were treated by S. Watson in 1871 in the "Botany of the King Expedition," and again in 1876 in Brewer and Watson's "Botany of California." B. L. Robinson's revision of *Sisymbrium* in the "Synoptical Flora," in 1895, was the next treatment of consequence. About the end of the last century and the beginning of the present two men were particularly active in pointing out hitherto unnoticed forms of *Descurainia*. E. L. Greene, from about 1887 to 1904, and P. A. Rydberg, from 1900 to about 1912, published a number of new species. We may disagree with their policy of giving specific rank to some of the types they found, but we must credit both these men with powers of keen observation. An attempt to clarify some of the puzzling forms was made by Macbride in 1915 in a short article in "Rhodora," in which he reviewed the relationships of the northern types of *Sisymbrium pinnatum* (or *S. brachycarpon*, as he treated it). The most recent and exhaustive monograph of the genus *Descurainia* is that by O. E. Schulz in "Das Pflanzenreich" (1924) containing all species known at that time. While Dr. Schulz is a remarkably keen observer, his

lack of familiarity with the American species as they occur in the field, with their range of variation and the environmental conditions under which they grow, and frequently the importance of their geographical distributions, has led him to many misunderstandings of rank and relationship similar to those characteristic of the work of the majority of investigators in this genus.

Our North American species, at least, are extremely variable, and attempts to identify isolated specimens frequently lead to confusing results. For this very reason, however, I have found the problem of the taxonomy of the group a most interesting one, since its members illustrate so clearly the influence of the varying environmental factors and geographical isolation upon the evolution of the species, as well as show the behavior toward one another of adjacent populations of varying degrees of genetic relationship. The species of *Descurainia*, as I delimit the genus, are rather few on this continent, but most of them are wide-spread in their distribution. When such a wide-spread species inhabits more than one type of environment it is common to find that it varies consistently in one or more characters from habitat to habitat. Through long-continued selection, either by the environment or by isolation, or both, these characters become fixed in the smaller populations. The fact that they have become *genetically* fixed may be demonstrated experimentally by growing their offspring under different environmental conditions without affecting the traits in question. These ecologically or geographically selected populations within a species apparently are not sufficiently altered in their chromosomal constitution to prevent them from hybridizing freely among themselves where they are contiguous, thus giving rise to fertile offspring of varying degrees of intermediacy between the parent stocks. All such populations I have treated as subspecies in the present revision, reserving the concept "species" for the larger populations made up of these interfertile groups. The species themselves are kept distinct in nature by their inability to hybridize with other species and produce strong fertile offspring. Sporadic variations within a species which are not naturally perpetuated by selection or isolation are not stable enough to warrant recognition in a taxonomic system, and while I shall call attention to several such minor, though frequent, variations in the following treatment I shall not assign them any valid position so far as nomenclature is concerned.

In view of the wide variations found within the North American species of *Descurainia* it would be well to consider briefly the reliability of some of the characters which are so frequently used for specific or subspecific determination. It may be said in general that none of the following characters is absolutely stable, especially as far as the subspecies are concerned, nevertheless certain combinations of charatcers occur consistently enough in an ecologically distinct population to warrant their use in determining the taxonomy of the species.

1. Growth habit. Two types of growth habit may be distinguished in our species. One has the central axis of the plant well developed, giving thus relatively tall and strict individuals in which the branches, when present, are mainly on the upper part of the plant and rather short. The second type is shorter, branching freely from the base with long spreading branches at the

expense of the central axis and giving a somewhat rounded, bushy individual. The first type is found consistently in *D. Richardsonii, impatiens, sophioides, californica, obtusa* and *Hartwegiana.* The second type is restricted to *D. Virlettii, streptocarpa* and *pinnata,* but in the latter species it is not characteristic of all the subspecies, nor is it always the only type found in those subspecies where it does occur. In general the tall type is characteristic of the more northern subspecies of *D. pinnata,* — that complex which has by some authors been accorded specific rank under the name *brachycarpa* and includes the subspecies *brachycarpa, intermedia, Nelsonii, filipes* and *Paysonii,* — while the bushy type is characteristic of the more southern, and particularly the Sonoran Zone, ecotypes* of the species.

2. Pubescence. The amount of pubescence and its distribution on the vegetative parts of the plant varies within certain limits according to conditions of moisture, or more particularly of shade, but in spite of this the character is fixed genetically in most of the forms, as I have found in experimental cultures, and furnishes a reasonably reliable basis for subspecific determination. For example, the southern complex of *D. pinnata* is without exception typically canescent, at least on the leaves, while the northern or *brachycarpa* complex is typically green.

3. Glandulosity. The reliability of glandulosity as a taxonomic character varies from species to species. In the southern complex of *D. pinnata* it is of slight value, since we frequently find both glandular and non-glandular individuals growing together in the same colony, and except in subsp. *paradisa* the character has not become localized in any particular ecotype. In the northern types of this same species the presence or absence of glands has become more definitely fixed in certain rather extensive geographical areas. In *D. Richadsonii* the glandular character of the herbage is definitely confined to one subspecies, *viscosa.* It occupies a geographical area for the most part distinct from that of the other subspecies, and glandulosity is furthermore associated genetically with other traits separating this subspecies from its close relatives. In *D. sophioides* and *streptocarpa* both glandular and non-glandular individuals may be found; but each of the remaining North American species seems to be clearly marked by the presence or absence of glands.

4. Leaf form. The size and shape of leaves and of leaf-segments vary considerably in most of the species. In general the leaves of *D. Richardsonii, californica, sophioides* and the northern subspecies of *pinnata* are all relatively large with rather broad segments, while the more southerly types of the latter species tend to have smaller leaves with much narrower segments and with a greater range of variation between the basal and the upper cauline leaves. In one or two members of this southern complex, however, non-conformity to this general southern type of leaf is so striking as to make it fairly reliable

* Ecotype: this term, proposed by Turesson, is in general synonymous with the subspecies as here interpreted, and I use it merely to direct special attention to the subspecies as the product of the selective action of a particular environment upon a part of a species-population.

for taxonomic use, especially when employed in conjunction with certain other characters.

5. Arrangement of seeds and shape of siliques. These two characters should be considered together, since they are largely dependent upon one another. The uniseriate and biseriate arrangement of the seeds within the silique has been used by almost all previous authors as the first point upon which the species have been separated. This has been the cause of a large part of the faulty identification of *Descurainia* specimens in all our herbaria. In some of the species, notably in *D. Richardsonii*, it is true that the seeds are always uniseriate and the siliques definitely linear and narrow. But it is equally true that in other species, more particularly in *D. pinnata*, the siliques vary considerably in relative width and the seeds may be arranged in either one or two rows, both arrangements frequently found on the same plant. However, the *pinnata* type of silique differs in shape from the *Richardsonii* type, by being relatively wider, shorter, and typically clavate rather than truly linear, and with the apex of the valves rounded rather than acutish as they are in the latter. This form of silique is typical of the southern subspecies, the northern ones displaying a greater tendency toward the narrow type. If the silique develops sufficient width and the seeds are not too large they apparently arrange themselves in two rows, but in a narrow silique or with relatively large seeds they are just as naturally crowded into one series.

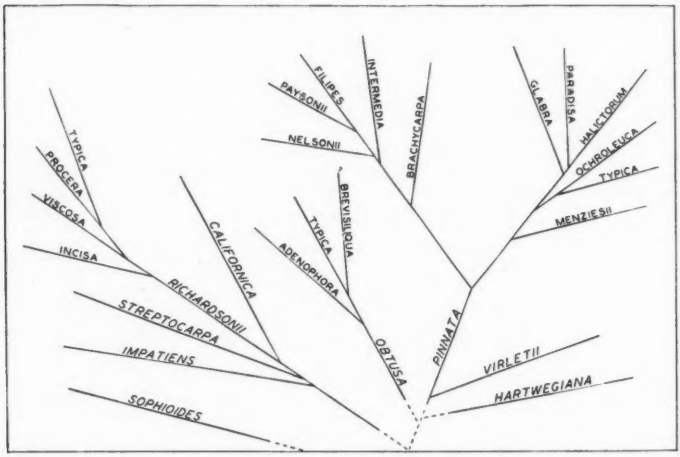
6. Orientation of pedicels and siliques. The position assumed by the pedicels and siliques with relation to the main axis of the racemes, i.e. whether wide-spreading, ascending, or closely appressed, is a very reliable taxonomic character. Apparent exceptions to this statement will frequently, I believe, prove to be hybrid forms.

7. Size of flowers. This character is of greater taxonomic significance than most previous investigators appear to have realized. In general we may recognize two types of flowers, a larger one in which the corolla ranges from 2 to 3 mm. in length, always considerably surpassing the calyx, and a smaller one in which the corolla is usually about 1.5 mm. or less in length and either barely equals the calyx or only slightly surpasses it. Flower size is not always constant throughout a species, but is ordinarily well fixed in any one subspecies.

8. Flower color. Two colors of corolla are found in the North American Descurainias, the more predominant one being a bright yellow, the other a pale sulphur-yellow which at times is almost white. This latter is particularly characteristic of certain of the southern subspecies of *D. pinnata*, though it is never found in the *brachycarpa* complex of that species. But we frequently find the bright yellow corollas even in those subspecies which are more typically pale-flowered. It is common to find in some of the ecotypes of the arid Southwest a distinctly rose-colored or rose-tipped calyx. While this trait is not always present it is frequently helpful in identifying specimens, since its presence does place the individual within a certain group of subspecies.

Our endemic species of *Descurainia* probably originated in the arid plateau regions to the southward and eastward of the Great Basin. The highlands of

Arizona and New Mexico and the western slopes of the central Rocky Mountain cordillera are the regions of the greatest concentration of distinct forms and the regions in which specific and subspecific characters appear still to be least constant in this genus. Migration presumably took place in all directions from this center, and where these movements have extended farthest, as in the Midwestern and Canadian plains and the region bordering the Gulf of Mexico, we find the greatest stability of characters. The arctic or subarctic species, *D. sophioides,* may have been derived from close relatives in Eurasia, such as *D. Sophia,* rather than from any North American species. There is another center of distribution of Descurainias in the Andean highlands of South America, but this does not appear to have contributed anything to our flora, unless it be *D. Hartwegiana,* even our other Mexican species showing close affinity with the more northern ones. The accompanying chart, based upon morphological resemblances and geographical distributions, attempts to show graphically the probable relationships to one another of the native North American species and subspecies.



The relationships of the native North American species of *Descurainia.*

DESCURAINIA Webb and Berth. Phyt. Can. 1:72. 1836.

(*Sisymbrium* Tourn. L. Sp. Pl. ed. 1, **2**:657. 1753, in part. *Sophia* Adans. Fam. Pl. **2**:417. 1763.)

Annual or biennial plants. Leaves pinnate to tripinnate, the earlier ones in a basal rosette which usually withers as the plant matures, typically reduced in size upward and becoming less compound on the upper portion of the stem. Inflorescence racemose, elongating on maturing. Flowers small, not over 3 mm. long. Sepals ovate, acute, green or yellow, frequently rose-tinged. Petals

yellow or whitish, clawed, the blades obovate, obtuse. Stamens yellow, included or slightly exserted. Fruit a narrow silique, its length typically 5-20 times its width (about 2-3 times in one subspecies), linear or clavate, terete or subterete, the valves opening from below upward, these more or less prominently 1-nerved; style short or obsolete, stigma truncate or somewhat capitate, entire. Seeds in 1 or 2 series in the locule, elliptical, yellowish to reddish-brown. Plants pubescent in varying degrees, but never totally glabrous; the pubescence consisting of stellately-branched hairs sometimes mixed with short simple hairs and frequently with stalked glands, particularly on the axis of the racemes.

Type species: *Descurainia Sophia* (L.) Webb.

KEY TO THE SPECIES

Siliques clavate or subclavate.
  Siliques parallel with axis of raceme ..... 10. *D. Hartwegiana*
  Siliques spreading from axis of raceme.
    Upper leaves 2-3-pinnate, the lower similar (see also 6d) ..... 7. *D. Virletii*
    Upper leaves simply pinnate, lower ones 1-2-pinnate ..... 6. *D. pinnata*
Siliques linear (more or less clavate in 5c).
  Seeds strictly uniseriate.
    Leaves 2-3-pinnate; siliques 20-40-seeded ..... 1. *D. Sophia*
    Leaves simply pinnate, the leaflets often deeply incised; siliques mostly 4-30-seeded.
      Inflorescence subumbellate at apex ..... 2. *D. sophioides*
      Inflorescence strictly racemose.
        Siliques attenuate at apex and tipped with the prominent style ..... 4. *D. californica*
        Siliques not attenuate at apex; the style short or obsolete.
          Lower pedicels subtended by bracts ..... 9. *D. impatiens*
          Lower pedicels not subtended by bracts ..... 3. *D. Richardsonii*
  Seeds biseriate in at least some of the siliques.
    Herbage canescent; pedicels never subtended by bracts ..... 5. *D. obtusa*
    Herbage not canescent; some of the pedicels usually subtended by bracts ..... 8. *D. streptocarpa*

1. *Descurainia Sophia* (L.) Webb; Prantl, in Engler and Prantl, Nat. Pfl. Fam. 3, Abt. 2:192. 1892.

(*Sisymbrium Sophia* L. Sp. Pl. ed. 1, **2**:659. 1753. *Sisymbrium parviflorum* Lam. Fl. Fran. **2**:519. 1778. *Hesperis Sophia* O. Ktze. Rev. Gen. Pl. **2**:935. 1891. *Sophia Sophia* Britt., in Britton and Brown, Ill. Fl. **2**:144. 1897. *Sophia parviflora* Standl. Contr. U. S. Nat. Herb. **22**:347. 1921.)

Annual or biennial plants, 25-75 cm. tall, short-branched above. Leaves broadly ovate or obovate to oblanceolate in outline, 1-9 cm. long, 2-3-pinnate, the ultimate lobes commonly linear, sometimes narrowly oblanceolate or even obovate. Leaves, stems and axis of the racemes, and occasionally the pedicels, from sparsely to quite densely stellate-pubescent. No glands present. Flowers yellow, calyx 2-2.5 mm. long, about equalling the corolla. Fruiting pedicels 8-15 mm. long, spreading about 45°. Siliques linear, somewhat torulose, 10-30 (typically about 20) mm. long, about 1 mm. wide, arcuate or less commonly straight, style short and blunt. Seeds uniseriate, 10-20 in each locule, oblong-elliptic, .75-1.5 mm. long. Septum of silique 2-3-nerved.

An Old World species which has been introduced and become well established throughout the United States, Canada and Alaska.

CALIFORNIA. *Plumas Co.:* Quincy, Keck 1664 (C, DS). *San Diego Co.:* Jacumba, Ferris & Bacigalupi 8228 (C, DS). OREGON. *Marion Co.:* Salem, J. C. Nelson 4288 (OSC). *Grant Co.:* Prairie City, Ferris & Duthie 722 (RM, W). IDAHO. *Blaine Co.:* Picabo, Macbride & Payson 2968 (C, RM). UTAH. *Weber Co.:* West Weber, Smith 1952 (RM). TEXAS. *Cameron Co.:* Brownsville, Runyon 712 (US). COLORADO. *Weld Co.:* Windsor, Osterhout 5496 (RM). NEBRASKA. *Holt Co.:* Ewing, Bates, June 20, 1898 (RM). DELAWARE. *Newcastle Co.:* Wilmington, Commons, June 12, 1900 (C). QUEBEC. Deschenes, Fr. Marie-Victorin 10092 (RM). SASKATCHEWAN. Saskatoon, Russell, June 5, 1934 (S, T). ALASKA. Gulkana, Bayne Beauchamp Exped. 14 (C).

2. *Descurainia sophioides* (Fisch.) O. E. Schulz, Pflanzenreich 4, Fam. 105:316. 1924.

(*Sisymbrium sophioides* Fisch. in Hook. Fl. Bor.-Am. **1**:61, tab. 20. 1833. *Sisymbrium Sophia* var. *sophioides* Benth. and Hook. Gen. Pl. **1**:78. 1862. *Sisymbrium arcticum* Fourn. Recherch. Crucif. 58. 1865. *Hesperis arctica* O. Ktze. Rev. Gen. Pl. **2**:934. 1891. *Sophia sophioides* Heller, Cat. N. Am. Pl. ed. 2, 4. 1900.)

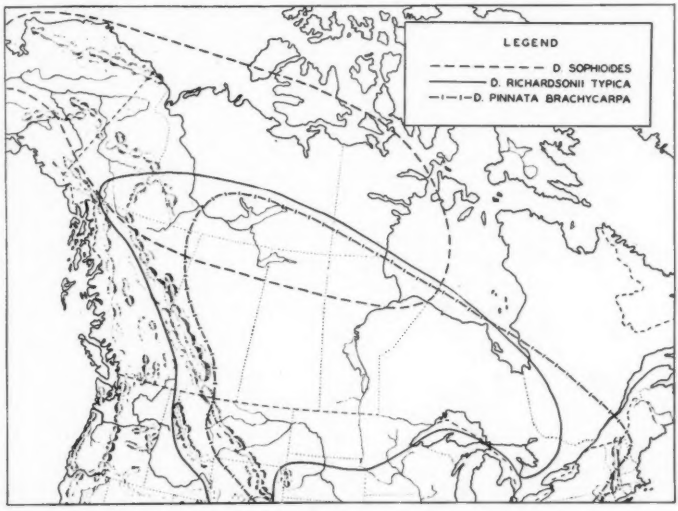
Annual or sometimes biennial plants reaching a height of 60 cm., mostly simple but at times short branched above, more rarely so below. Leaves broadly ovate in outline, 3-9 cm. long, pinnate or less commonly bipinnate with the usually lanceolate pinnae deeply incised. Plants varying from nearly glabrous to moderately pubescent with mixed simple and stellate hairs. Upper portion of stems and axis of racemes sometimes glandular. Elongation of the racemes is relatively slow near the apex, so that the flowers are surpassed by a dense subumbellate cluster of young siliques crowning an elongated raceme of older siliques. Flowers bright yellow; calyx 1.5-2 mm. long, corolla 2-2.5 mm. long. Siliques 10-20 mm. long, 1 mm. or less in width, noticeably flattened, typically arcuate, curving over the flowers when young, spreading when older; fruiting pedicels 4-5 mm. long, spreading 45°-80°, becoming reflexed in age. Seeds uniseriate (rarely in two crowded rows), about 15-20 in each locule, 1-1.3 mm. long and relatively slender.

An arctic and subarctic species with a range extending from Hudson Bay (York Factory, according to Hooker) westward across the Northwest Territories, Yukon and Alaska, and north to the Arctic Ocean. It does not occur in the more temperate regions west and south of the Coast Ranges in British Columbia, Yukon and Alaska. (Map 1.)

ALASKA. Yukon River, Bates, 1881 (GH); Anvik, Carpenter 13 (GH); Arakamtchetchene Id., Bering Straits, Wright, without date (GH); Pastoliak River, Newhall, 1899 (C); Porcupine River, Turner, 1891 (C); Paxon's, Went, 1934 (C); Tenana, Henderson 14774 (Or); Rampart, Henderson 14773 (Or); "Alaska," Meyer, 1895 (DS). YUKON. Dawson, Eastwood 435 (GH), Henderson 14777 (Or); Herschel Id., Johansen 192 (GH), Seale, 1896 (DS); "Yukon Terr.," MacLean, 1898-1901 (C, GH). NORTHWEST TERRITORIES. Letty Harbor, Father Dutilly 317 (GH). BRITISH COLUMBIA. Upper Alloknajik Lake, McKay, July, 1882 (GH).

3. *Descurainia Richardsonii* (Sweet) O. E. Schulz, Pflanzenreich 4, Fam. 105:318. 1924.

Slender biennial plants 30-120 cm. in height, the stems simple below but usually branching above. Leaves ovate to broadly lanceolate or oblanceolate in outline, 1.5-10 cm. long, the upper simply pinnate with entire or lobed margins, the lower from simply pinnate to again pinnatifid, the ultimate segments mostly broad and obtuse (narrower and more acute in subsp. *typica*). Flowers from pale to bright yellow, of moderate size varying with the subspecies. Siliques narrowly linear, 5-15 mm. long, .5-1.5 mm. wide, tapering rather abruptly at either end, usually more or less arcuate but sometimes

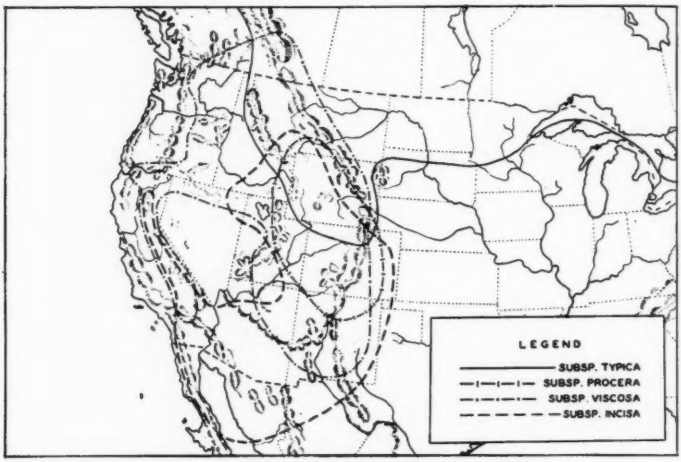


Map 1. Distribution of *Descurainia sophioides*, and the northward extension of *D. Richardsonii* subsp. *typica* and of *D. pinnata* subsp. *brachycarpa*.

straight, apex of the valves acutish, style short and blunt. Seeds strictly uniseriate in the silique, 4-14 in each locule, reddish-brown, oblong to elliptical.

This species is an inhabitant of cool or moderate climates and for the most part occupies the mountains of the Western United States (Maps 1 and 2). One subspecies, *typica*, is a northern plains ecotype. Its most striking trait, apparently an adaptation to its drier environment, is the dense pubescence of its stems and leaves. It is further marked by its appressed pedicels and siliques and by the complete absence of glandulosity. The other three subspecies occupy the mountains which rim the Great Basin, and the higher isolated ranges rising from the plateaus to the north and south of it. In the central Rocky Mountains, contiguous to the range of subsp. *typica*, is subsp. *procera*, differing from the former chiefly in the fact that it is almost glabrous or only moderately pubescent, and in its leaves being usually more dissected with broader and blunter segments. This form retains the appressed pedicels and

siliques and the non-glandular character of subsp. *typica*. The subspecies *viscosa* and *incisa* are somewhat less distinct from one another, both as to range and as to the characters which separate them. The area occupied by each roughly takes the form of a crescent. The center of distribution of *viscosa* is in the mountains to the north of the Great Basin, while *incisa* is centered to the southward in New Mexico and Arizona, the horns of their crescents extending respectively southward and northward in the Rocky Mountains and the Sierra Nevada. In the regions where their ranges overlap it is common to find *viscosa* in moist situations, such as around springs and along water-



Map 2. Distribution of *Descurainia Richardsonii*.

courses, while *incisa* commonly grows in the shade of trees in drier places. Subsp. *viscosa* is the only form of this species typically having glandular herbage, and is further distinguishable from its two northern relatives by its more spreading pedicels and siliques. Subsp. *incisa* is typically non-glandular and has still wider-spreading pedicels and siliques and smaller flowers than *viscosa*, although the two latter traits are frequently approximated by individuals of *viscosa* found in New Mexico. In a rather limited area in the central Rocky Mountains where the populations of both subspecies *viscosa* and *procera* are particularly well developed, hybridization has apparently given rise to a form to which Rydberg assigned specific standing with the name *Sophia glandulifera* (Bull. Torrey Club 28:281. 1901). This has the short appressed siliques of *procera* and the glandulosity of *viscosa*. Outside of this particular area the short appressed fruits in dense racemes are never associated with *viscosa*, nor is *procera* ever glandular. A few specimens of this hybrid form are cited separately following those of subsp. *viscosa*.

KEY TO THE SUBSPECIES

Pedicels and siliques closely appressed to the axis of the raceme.
- Plants canescent ..... 3a. subsp. *typica*
- Plants moderately pubescent to nearly glabrous ..... 3b. subsp. *procera*

Pedicels and siliques spreading or ascending.
- Plants glandular ..... 3c. subsp. *viscosa*
- Plants not glandular ..... 3d. subsp. *incisa*

3a. **Descurainia Richardsonii** subsp. **typica** nom. nov.

(*Sisymbrium canescens* Richards. in Bot. App. Frankl. Narrat. Journ. 744. 1823. Not Nutt. 1818. *Sisymbrium Richardsonii* Sweet, Hort. Brit., ed. 2, 30. 1830. *Sisymbrium canescens* var. major Hook. Fl. Bor.-Am. **1**:62. 1840. *Descurainia Richardsonii* O. E. Schulz, loc. cit. 1924. *Sophia Richardsoniana* Rydb. Brittonia **1**:89. 1931. *Sisymbrium Richardsonianum*, erroneously attributed to Sweet by Rydb. Brittonia **1**:89. 1931.)

Whole plant canescent, non-glandular. Ultimate leaf-segments narrowly lanceolate to linear. Flowers pale yellow, calyx 1-1.5 mm. long, corolla about equalling or barely surpassing it. Fruiting pedicels 3-6 mm. long, spreading 5°-20° from the axis of the raceme. Siliques 5-10 mm. long, closely appressed. Seeds 4-8 in each locule.

From Yukon and the Great Slave Lake region through the Canadian plains to the Great Lakes and North Dakota; on the eastern and occasionally western slopes of the Rocky Mountains as far south as Northern Colorado. Type collected by Richardson between Hudson Bay and Great Slave Lake.

NORTHWEST TERRITORIES. "America Septentrionalis," Richardson (photograph of type, BM); Fort Providence, Preble & Cary 31 (US); Fort Resolution, E. A. & A. E. Preble 148 (US); Fort Simpson, Taylor, July 25, 1892 (US). YUKON. Bear Creek, near Lake Desert d'Asch, Müller, August 6, 1920 (US). ALBERTA. Banff, Macoun, July 4, 1891 (T); Wood Buffalo Park, Raup 2464 (C, GH). SASKATCHEWAN. Saskatoon, Fraser, July 13, 1935 (S); "Saskatchewan," Bourgeau, 1857-58 (GH). MANITOBA. Winnipeg, Macoun, August 2, 1872 (McG); Plains of Manitoba, Macoun, August 7, 1872 (McG), Macoun, August 8, 1872 (McG); Lake Winnipeg Valley, Bourgeau, 1857 (GH). ONTARIO. Stokes Bay, Krotkov 9095 (T); Mamainse Point, Algoma Dist., Taylor (?) 1959 (T). BRITISH COLUMBIA. Lake Atlin, W. A. & C. B. Setchell & H. E. & S. T. Park, July 10, 1930 (C). NORTH DAKOTA. *Nelson Co.:* Tolna, Tufte 34 (RM). *Turner Co.:* Maza, Kildahl, August 2, 1900 (RM). *La Moure Co.:* Kulm, Brenkle, Sept., 1910 (RM). MINNESOTA. *Pope Co.:* Glenwood, Taylor, August, 1891 (GH). WYOMING. *Teton Co.:* Jackson Hole, Williams 298 (RM). *Sublette Co.:* Hoback River, Detling 2287 (Or). *Uinta Co.:* Evanston, Williams, July 10, 1897 (US). COLORADO. *Gilpin Co.:* Between Tolland and Rollinsville, Overholts 10160 (C, Col). MONTANA. *Beaverhead Co.:* Hell Roaring Creek, Cronquist 722 (ISB). IDAHO. *County undetermined:* Bear Creek below Parker Mountain, Macbride & Payson 3288 (C. DS, RM, US).

3b. **Descurainia Richardsonii** subsp. **procera** (Greene) comb. nov.

(*Sisymbrium Hartwegianum* of authors, not Fourn. *Sisymbrium incisum* var. *Hartwegianum* S. Wats. in Brew. and Wats. Bot. Calif. **1**:41. 1876, excl. synon. *Descurainia Hartwegiana* Britt. Mem. Torrey Club **5**:173. 1894, excl. synon. *Sophia procera* Greene, Pitt. **4**:199. 1900. *Sisymbrium procerum* K. Schum. in Just, Bot. Jahresber. 28 (1900), **1**:434. 1902. *Sophia brevipes* Rydb. Bull. Torrey Club **29**:238.

1902. *Descurainia Richardsonii* var. *macrosperma* O. E. Schulz, Pflanzenreich 4, Fam. **105**:319. 1924.)

Leaves commonly nearly glabrous, at times moderately pubescent, the stem and axis of the racemes varying from glabrous to moderately pubescent. Plants typically non-glandular. Flowers pale yellow; calyx 1-1.5 mm. long, corolla 1-2 mm. long. Fruiting raceme dense. Fruiting pedicels 2-6 mm. long, spreading 5°-20° or rarely as much as 40°. Siliques 6-12 mm. long, 1-1.5 mm. wide, closely appressed to the axis of the raceme. Seeds 1-1.5 mm. long.

In shaded or moist situations in the central Rocky Mountain area, from Southern Montana to Northern New Mexico. The type was collected near Pagosa Peak, in Colorado.

Since Watson this form has been by most American authors identified with *D. Hartwegiana* (Fourn.). The latter, however, is a Mexican and South American species not closely related to ours. Some authors have assumed also that this was Nuttall's *Sisymbrium canescens* var. *brevipes* (Torrey and Gray, Fl. N. Am. 1:92. 1838). However, his only characterization of the variety, "siliques usually longer than the pedicels," is very indefinite and could be applied to a number of Rocky Mountain Descurainias.

COLORADO. *Mineral Co.:* Near Pagosa Peak, C. F. Baker 360 (type collection, C, RM, US); Summit Wolf Creek Pass, San Juan Mts., Wolf 3014 (DS). *Ouray Co.:* Ouray, Nelson 9842 (RM); Ridgway, E. B. & L. B. Payson 3854 (RM). *San Miguel Co.:* Near Trout Lake, E. B. & L. B. Payson 4216 (RM). *Grand Co.:* Hot Sulphur Springs, Ramaley & Robbins 3571 (C, Col, RM). WYOMING. *Sublette Co.:* Horse Creek, 7 miles west of Merna, E. B. & L. B. Payson 2743 (RM, US); Gros Ventre Mts., E. B. & L. B. Payson 3043 (C, RM); Saltlick Mt., E. B. & L. B. Payson 2959 (C, RM, US). *Lincoln Co.:* Cottonwood Lake, Payson & Armstrong 3770 (Col, RM). *Uinta Co.:* Mill Creek, near Bear River, E. B. &. L. B. Payson 4943 (DS, RM, US). *Yellowstone Park:* Yellowstone Lake, A. & E. Nelson 6925 (RM). *Platte Co.:* Wheatland, Nelson 3073 (RM). *Carbon Co.:* Copperton, Tweedy 4481 (US). MONTANA. *Park Co.:* Electric Peak, Rydberg & Bessey 4202 (US). *Gallatin Co.:* Bozeman, Jones, June 20, 1902 (US). UTAH. *Grand Co.:* LaSal Mts., E. B. & L. B. Payson 3969 (C, DS, RM). *Salt Lake Co.:* Alta, M. E. Jones 1117 (type collection of *D. Richardsonii* var. *macrosperma* O. E. *Schulz*, Po), M. E. Jones, August, 1379 (US). *San Juan Co.:* Dry Wash, Abajo Mts., Rydberg & Garrett 9630 (US). NEW MEXICO. *Colfax Co.:* Vicinity of Ute Park, Standley 13498 (US), Standley 14475 (US). *Taos Co.:* Rio Fernandez de Taos Canyon, Eggleston 19113 (US). *Sandoval Co.:* Placitas, Sandia Mts., Wooton, August 3, 1910 (US). *Rio Arriba Co.:* Vicinity of Brazos Canyon, Standley & Bollman 11205 (US).

3c. **Descurainia Richardsonii** subsp. **viscosa** (Rydb.) comb. nov.

(*Sisymbrium californicum* S. Wats. Bot. King Exped. 23. 1871, excl. synon. *Sophia californica* Rydb. Bull. Torrey Club **29**:238. 1902, excl. synon. *Sophia viscosa* Rydb. Bull. Torrey Club **29**:238. 1902. *Sisymbrium incisum* var. *californicum* Blankinship, Mont. Agric. Coll. Sci. Studies, Bot. **1**:60. 1905. *Sisymbrium viscosum* Blankinship, Mont. Agric. Coll. Studies, Bot. **1**:60. 1905. *Descurainia Rydbergii* O. E. Schulz, Pflanzenreich 4, Fam. **105**:319. 1924.)

Although Watson and Rydberg both applied the specific name *californica* to this unit their synonymy referred to different types. *Sismybrium californicum* S. Wats. was based upon *Smelowskia* (?) *californica* Gray, while *Sophia californica* Rydb. was based upon Torrey and Gray's *Sisymbrium canescens*

var. *californicum*, which is undoubtedly *Descurainia pinnata* subsp. *Menziesii* (DC.)

Plants moderately to densely pubescent with mixed simple and stellate hairs, but not canescent. Stem, axis of the racemes, and sometimes the pedicels thickly beset with glandular hairs, the leaves occasionally sparsely so. Flowers bright yellow, the largest in this species; calyx 1.5-2.5 mm. long, corolla 2-3.5 mm. long. Fruiting pedicels 6-10 (rarely 12) mm. long, spreading 40°-80°. Siliques 9-15 mm. long, either forming a straight line with the pedicels or at times standing nearly erect.

At high altitudes in the Sierra Nevada of California, northward east of the Cascade summit as far as Central Washington and thence eastward to the Rocky Mountains where it extends from Southern Alberta to New Mexico. Locally in the higher mountain ranges of the Great Basin and the Columbia Plateau. Type: Beaver Canyon, Idaho, C. L. Shear 3029, in the Herbarium of the New York Botanical Garden.

CALIFORNIA. *San Bernardino Co.:* Santa Ana River, San Bernardino Mts., J. & H. W. Grinnell 290 (US). *Tulare Co.:* Hocket Trail to Little Kern River, Dudley 1072 (DS); Mineral King, M. S. Baker 4191 (RM), Coville & Funston 1477 (US); Big Tree Road, near Camp 129, Brewer 1944 (US). *Mariposa Co.:* Indian Creek, Yosemite Nat'l. Park, Hall 9167 (C). *Fresno Co.:* S. Fork San Joaquin River, Lorraine & Ferris 9226 (DS); N. Fork Kings River, Hall & Chandler 430 (C). *Madera Co.:* Upper San Joaquin, Congdon, August 19, 1895 (C). *Alpine Co.:* Twin Lakes, Hansen 569 (DS). *El Dorado Co.:* Mt. Tallac, Hall & Chandler 4609) (C). *Placer Co.:* Summit Hotel, Heller 12911 (Col, DS, US). *Siskiyou Co.:* Head of Shackleford Creek, Butler, August 4, 1908 (C). OREGON. *Jackson Co.:* Mt. Ashland, Peck 1995 (W); Low Gap Trail to Whiskey Peak, Peck 16464 (W). *Lake Co.:* Gearhart Mt., Constance 9539 (Or). *Harney Co.:* Steins Mts., Griffiths & Morris 577 (US). *Malheur Co.:* Beulah, Leiberg 2302 (Or, US). *Wheeler Co.:* Ochoco Nat'l. Forest, Warg, July 25, 1923 (OSC). *Grant Co.:* Strawberry Lake, Ferris & Duthie 769 (DS), Peck 10274 (DS). *Union Co.:* Hilgard, Peck 17462 (DS, W). *Wallowa Co.:* Aneroid Lake, Ferris & Duthie 1121 (DS, RM). WASHINGTON. *Chelan Co.:* Leavenworth, Thompson 8433 (C, Th, US). *Okanogan Co.:* "Under fir trees, 6800 ft.," Fiker 1055 (Th, US). IDAHO. *Clark Co.:* Beaver Canyon, C. L. Shear 3029 (type, NY), C. L. Shear 3031 (NY). *Blaine Co.:* Head of Boulder Creek Canyon, Thompson 14131 (C, GH, Th). *Custer Co.:* Lost River Mts., Henderson 3884 (US). *Valley Co.:* Brundage Mt., Constance & Pennell 1968 (C). *Fremont Co.:* Howard Springs, Targhee Pass, Detling 2264 (Or). ALBERTA. Laggan, Rocky Mountain Park, Macoun, July 13, 1904 (US). MONTANA. *Glacier Nat'l. Park;* Altyn Peak, Standley 15973 (US); Cracker Lake, Standley 15825 (US); Iceberg Lake, Standley 15369 (US). WYOMING. Sublette Co.: Head of Pole Creek, Nelson 1321 (NY, US). *Yellowstone Nat'l. Park:* Table Mt., Nelson, June 30, 1895 (RM). *Albany Co.:* Laramie Nelson 1421 (RM); Trout Lake, A. & E. Nelson 5848 (RM, NY, US). COLORADO. *Jackson Co.:* King's Canyon, E.B. & L.B. Payson 4294 (RM). *Larimer Co.:* Estes Park, Cooper 310 (RM). *Boulder Co.:* Eldora, Robbins 2388 (Col). *Archuleta Co.:* Upper Navajo River, San Juan Mts., Ownbey 1413 (ISB). *El Paso Co.:* Petrified Stump, Letterman, August 3, 1884 (US). NEW MEXICO. *Valencia Co.:* Canyon Colorado, Mt. Taylor, Eggleston 18701 (US). *Catron Co.:* Willow Creek, Mogollon Mts., Wolf 2656 (DS); Mogollon Mts., Rusby 22 (Or, US). *Lincoln Co.:* Sierra Blanca, Sacramento Mts., Eggleston 18827 (US). *Dona Ana Co.:* Filmore Canyon, Organ Mts., Wooton, Oct. 29, 1904 (US). *Sandoval Co.:* Rito de los Frijoles, Robbins 8266 (Col). *County undetermined:* Fendler 31 (GH). ARIZONA. *Apache Co.:* Hannagan Meadow, White Mts., Kearney & Peebles 12366 (US). *Coconino Co.:* Walnut Canyon, McDougal, July 1, 1891 (US). UTAH. *Garfield Co.:* Mt. Ellen, Henry Mts., Jones 5684bj (US).

County undetermined: Wahsatch Mts., King Exped., S. Watson 99 (US). NEVADA. *Elko Co.:* Jarbidge, Nelson & Macbride 1965 (RM, US); Martin Creek, Pine Mt., Kennedy 4270 (DS); E. Humboldt Mts., King Exped., S. Watson 99 (US).

Specimens of the hybrid form, subsp. *viscosa* x subsp. *procera*, referred to n the introductory remarks on this species, are the following:

MONTANA. *Jefferson Co.:* Alhambra, Brandegee, July 24, 1898 (C). *Park Co.:* Suksdorf Gulch, Wilsall, Suksdorf 108 (GH). WYOMING. *Lincoln Co.:* Cottonwood Lake, Payson & Armstrong 3705 (RM). *County undetermined:* Rolling plains between Sheridan and Buffalo, Tweedy 3592 (Type of *Sophia glandulifera* Rydb., NY, isotype, US). COLORADO. *Larimer Co.:* Powder Canyon, Osterhout 5666 (RM). *Grand Co.:* Hot Sulphur Springs, Ramaley & Robbins 3549 (C, Col, RM), Wooton, August, 1914 (US).

3d. **Descurainia Richardsonii** subsp. **incisa** (Engelm.) comb. nov.

(*Sisymbrium incisum* Engelm. in Gray, Pl. Fendl. 8. 1849. *Hesperis incisa* O. Ktze. Rev. Gen. Pl. **2**:934. 1891. *Descurainia incisa* Britt. Mem. Torrey Club **5**:173. 1894. *Sisymbrium incisum* var. *Sonnei* Rob. in Gray, Syn. Fl. N. Am. **11**:140. 1895. *Sophia Sonnei* Greene, Pitt. **3**:95. 1896, as to synonymy. *Sophia incisa* Greene, Pitt. **3**:95. 1896. *Sophia leptophylla* Rydb. Bull. Torrey Club **29**:239. 1902. *Sophia serrata* Greene, Leaflets Bot. **1**:96. 1904. *Sophia purpurascens* Rydb. Bull. Torrey Club **31**:556. 1904. *Sisymbrium leptophyllum* Nels. and Macbr. Bot. Gaz. **56**:475. 1913. *Descurainia serrata* O. E. Schulz, Pflanzenreich 4, Fam. **105**:317. 1924. *Descurainia incisa* var. *leptophylla* O. E. Schulz, Pflanzenreich 4, Fam. **105**:321. 1924.)

Plants subglabrous to moderately pubescent, typically non-glandular. Leaves simply pinnate with 1-6 pairs of pinnae, the margins of these from entire to deeply incised, the teeth when present either rounded or acute. Flowers pale yellow; calyx 1-1.5 mm. long, corolla 1.5-2 mm. long. Fruiting pedicels 4-10 mm. long, spreading 45°-80°. Siliques 8-15 mm. long, standing at an angle of 10°-45° with the axis of the raceme. Seeds about .75 mm. long, 6-14 in each locule.

In the Rocky Mountain region from Chihuahua to Southern Montana, and from Sonora and Baja California through the southern and central Sierra Nevada of California. Type: Mora River, New Mexico, Fendler 29, in the Gray Herbarium.

Two segregates have been based largely upon differences in leaf form which appear to be too unstable in this subspecies to permit of their being used taxonomically. Certain New Mexican specimens on which the leaflet margins were unusually sharply serrate served as the type for Greene's *Sophia serrata*. In the same way, some of the Sierra Nevada plants have much-divided leaves whose leaflets are quite rounded. This was particularly true of C. F. Sonne's collections from Nevada County, upon which Robinson based his *Sisymbrium incisum* var. *Sonnei*.

CHIHUAHUA. 150 mi. north of Batopilas, Palmer 421 (GH, US). BAJA CALIFORNIA. La Encantada, Sierra San Pedro Martir, Wiggins & Demaree 4927 (DS). CALIFORNIA. *San Bernardino Co.:* Seven Oak Camp, San Bernardino Mts., Grant, June 11, 1901 (DS). *Tulare Co.:* Olancha Mt., Hall & Babcock 5293 (C); Natural Bridge Meadow, Culbertson 4267 (C, DS). *Inyo Co.:* Sobrina Lake, Jones, August 25, 1926 (GH). *Nevada Co.:* Truckee, Sonne 19 (Type of *Sisymbrium incisum* var. *Sonnei*, GH), Sonne, June, 1885 (DS),, Sonne 6404a (C), Sonne 6404b (C), Sonne

526 (C). *Lassen Co.:* Harvey Valley, J. T. Howell 12476 (DS). ARIZONA. *Apache Co.:* Carizo Mts., Standley 7377 (US).

NEW MEXICO. *Otero Co.:* Tularosa Creek, Wooton, August 18, 1899 (C, RM, US). *Catron Co.:* W. Fork of the Gila, Mogollon Mts., Metcalfe 346 (RM); Luna, Eggleston 20288 (US). *Lincoln Co.:* White Mts., Wooton & Standley 3541 (OSC, US), Wooton 229 (C, GH, RM, US). *San Miguel Co.:* Las Vegas, Cockerell, 1899 (NMC). *Mora Co.:* Mora River, Fendler 29 (type, GH). *Sandoval Co.:* Rito de los Frijoles, Robbins 8226 (Col). *Santa Fe Co.:* Glorieta, Standley 5275 (US). *Colfax Co.:* Vicinity of Ute Park, Standley 13733 (US). *Taos Co.:* Taos Canyon, Castetter 1811 (RM). *Rio Arriba Co.:* Chama, Standley 6507 (US). *San Juan Co.:* Farmington, Standley 7169 (US). *Grant Co.* Mimbres River, south end of Black Range, Metcalfe 1069 (type collection of *Sophia serrata*, GH, US). TEXAS. *El Paso Co.:* El Paso, Vasey, 1880 (Col.) COLORADO. *Boulder Co.:* Ward, Schmoll 431 (Col, RM). *Huerfano Co.:* Cuchara Valley, Stigall, July 6, 1934 (Col). *San Miguel Co.:* Telluride, Shear, August, 1900 (US). *Ouray Co.:* Red Mountain, Underwood & Selby 275 (type of *Sophia purpurascens*, NY). *Larimer Co.:* Foothills, Crandall & Cowen 55 (type of *Sophia leptophylla*, NY). *Routt Co.:* Hawkes Ranch, Fish Creek, Payson, Sept., 1921 (RM); Steamboat Springs, Crandall, July 25, 1891 (US). UTAH. Carbon *Co.:* Castlegate, Jones 5485 (RM). *Daggett Co.:* Linwood, Williams 418 (RM). *Salt Lake Co.:* Red Rock Canyon, Rydberg 6090 (RM). *County undetermined:* Carter Dugway, Uinta Mts., Goodding 1408 (C, RM, US). NEVADA. *Elko Co.:* Deeth, Heller 9255 (US). WYOMING. *Albany Co.:* Antelope Basin, Nelson 7466 (NY, RM, US). *Sweetwater Co.:* Centennial Hills, Nelson 1686 (RM, US). *Lincoln Co.:* Alpine, Payson & Armstrong 3609 (RM). IDAHO. *Bannock Co.:* Pocatello Creek, Davis 520 (ISB), Davis 520a (ISB). *Blaine Co.:* Ketchum, Nelson & Macbride 1241 (DS, RM). *Canyon Co.:* Parma, Davis 110 (ISB). *Custer Co.:* Placer and Warm Spring Creeks, Sawtooth Mts., Woods & Tidestrom 2668 (US). *Camas Co.:* Soldier Mts., Henderson 3247 (US). MONTANA. *Gallatin Co.:* Mt. Bridger, Blankinship 66 (RM, US).

4. *Descurainia californica* (Gray) O. E. Schulz, Pflanzenreich 4, Fam. 105:330. 1924.

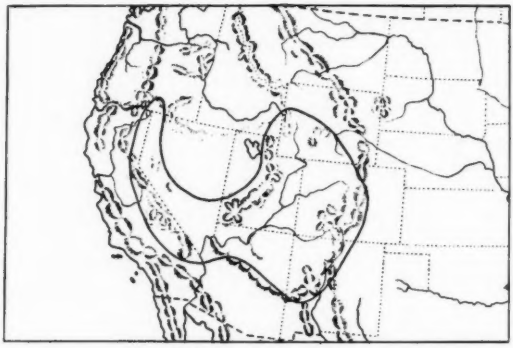
(*Smelowskia* (?) *californica* Gray, Proc. Am. Acad. **6**:520. 1865. *Sisymbrium californicum* S. Wats. Bot. King Exped. 23. 1871, as to synonymy. *Sophia Sonnei* Greene, Pitt. **3**:95. 1896, excl. synon. *Sophia leptostylis* Rydb. Bull. Torrey Club **39**:325. 1912.)

Schulz's citation of specimens in "Das Pflanzenreich" indicates that he did not have this species well defined. Baker 1344 is *D. californica*, but Heller 8218 is *D. pinnata* subsp. *glabra*, and Sandberg & Leiberg 161 and Suksdorf 2463 and 2728 are *D. pinnata* subsp. *Nelsonii*.

Biennial plants or at times apparently flowering the first year; 28-85 cm. tall, branched above with usually short slender branches. Leaves 1.5-6 cm. long, obovate to oblanceolate in outline, simply pinnate with 2-4 pairs of pinnae, the latter lanceolate, acute or obtuse, their margins from entire to serrate or incised, the teeth typically blunt. Leaves and lower portions of stems moderately pubescent, upper portions of stems and axis of racemes from moderately pubescent to glabrous; no glands present on the plant. Calyx about 1 (or 1.5) mm. long, yellow or greenish, barely exceeded by the yellow corolla. Fruiting pedicels 3-7 mm. long, spreading 15°-45°. Siliques 3-7 mm. long, 1-1.25 mm. wide at the widest point, tapering gradually to the base and long-acute at the apex and thus more or less fusiform, straight or

slightly curved, typically standing nearly or quite erect but often spreading as much as 45° from the axis; style prominent, .5-.75 mm. in length. Seeds uniseriate, 1-3 in each locule, 1-1.5 mm. long, elliptical, light brown.

In the mountain ranges of the southern part of the Great Basin and in Northern Arizona and Northwestern New Mexico; northward on the western slopes of the Rocky Mountains to Jackson Lake, Wyoming, and on the eastern slopes of the Sierra Nevada of California; Southeastern Oregon. (Map 3.) Type collected by Brewer at Mono Lake, California.



Map. 3. Distribution of *Descurainia californica.*

The type sheet in the Gray Herbarium is made up of two of Brewer's specimens, only one of which has both fruits and flowers and which I am therefore accepting as the type specimen. The other is in flower only. The data accompanying the specimens are simply the following: "1745, Mt. Dana. 1850, Mono Lake," with no indication of how the numbers are to be applied to the two plants. However, a specimen of Brewer's no. 1850 in the United States National Herbarium is in good fruit and matches very closely the fruiting specimen in the Gray Herbarium. I have no doubt the two are of the same collection.

In the central Rocky Mountain area there occurs occasionally a form of this species which shows certain marked variations from the typical form described above. The siliques are longer (up to 10 mm.) with 3-6-seeded locules and the styles are shorter and blunter but the apex of the silique is still attenuate. This form occupies an area in common with the typical form and apparently has no different ecological distribution. It is probably only a local variation, but only experimental work will definitely determine this point.

CALIFORNIA. *Mono Co.:* Mono Lake, Brewer 1850 (type, GH, isotype, US); Mt. Dana, Brewer 1745 (co-type, GH), Evans, July, 1901 (DS); Bridgeport, Abrams 13638 (DS); Slate Creek Basin, Clausen 1121 (C). *Inyo Co.:* Loch Leven Fork of Bishop Creek, Ferris 8856 (C, DS). *Tulare Co.:* Kern Canyon at Rock Creek, Hall & Babcock 5561 (C). *Nevada Co.:* Washoe Mts., Davy 3164 (C). *San Bernardino*

Co.: Bonanza, Providence Mts., Munz & Harwood 3439 (RM). OREGON. *County undetermined:* Silver Lake to Ft. Klamath, Exped. to Fossil Lake, 1901 (C). NEVADA. *Washoe Co.:* Hunter Creek, Kennedy 1920 (DS). *Douglas Co.:* Glenbrook, Baker 1344 (C, GH). *Esmeralda Co.:* Chiatovitch Creek, White Mts., Duran 3097 (C, DS, RM, US). *Clark Co.:* Little Falls, Clokey 5482 (C, US). UTAH. *Salt Lake Co.:* Big Cottonwood Canyon, Rydberg & Carlton 6629 (type of *Sophia leptostylis*, NY, isotype, US), Rydberg & Carlton 6498 (NY), Rydberg 6806 (NY, RM, US), Garrett 1932 (RM, US). *Utah Co.:* Aspen Grove, Garrett 3594 (RM). *Sevier Co.:* Fish Creek Canyon, Garrett 2578 (NY). *Beaver Co.:* Milford, Rydberg & Carlton 6283 (NY). *Garfield Co.:* Mt. Ellen, Henry Mts., Jones 5684g (C, DS, NY, US). *San Juan Co.:* Head of Dry Wash, Abajo Mts., Rydberg & Garrett 9628 (NY). ARIZONA. *Apache Co.:* Segi Canyon, Navajo Ind. Res., Clute 119 (RM). NEW MEXICO. *Socorro Co.:* Datil Forest, Eggleston 17218 (US); Lower Largo, Datil Forest, Talbot 75 (US). COLORADO. *Ouray Co.:* Ouray, Osterhout 5278 (RM). *Mesa Co.:* Pinon Mesa, Rollins 1935 (GH). *County undetermined:* Pikes Peak region, Schneider 55 (RM). WYOMING. *Sublette Co.:* Gros Ventre Mts., E. B. & L. B. Payson 3029 (C, Col, OSC, RM, US). *Lincoln Co.:* Cottonwood Lake, Payson & Armstrong 3800 (GH, RM); Alpine, Payson & Armstrong 3389 (Col, RM). *Teton Co.:* Jenny Lodge, Jackson Lake, Detling 2282 (Or).

5. *Descurainia obtusa* (Greene) O. E. Schulz, Pflanzenreich 4, Fam. 105:321. 1924.

Coarse, strict, biennial plants, 50-125 cm. tall; stems either simple or short-branching above, or if branching below the plant not bushy. Leaves 1-6 cm. long, ovate or obovate to oblanceolate in outline, simply pinnate with 2-5 pairs of pinnae, these narrowly lanceolate or oblanceolate to linear, typically obtuse, their margins entire to serrate or even incised. Stems and leaves and sometimes other parts densely and finely canescent with stellate or mixed stellate and simple hairs. Calyx greenish-white to pale yellow, frequently rose-tipped; corolla whitish to light yellow. Siliques linear, 5-20 mm. long, from less than 1 mm. to 1.5 mm. wide, tapering abruptly at either end, straight or slightly arcuate. Styles short or obsolete, the stigmas typically broadly and flatly capitate.

A species of the arid Southwestern United States and Northern Mexico, found largely in the mountains or on the high plateaus of that region (Map 4). It occurs in three distinct forms, the most widespread of which, subsp. *typica*, is in general an inhabitant of the cooler situations within its range, such as the *Pinus ponderosa* belt of Northern Arizona. This and subsp. *adenophora* are distinctly separable on the basis of several characters which are fairly well correlated in each, viz., presence or absence of glands, angle of spreading of the fruiting pedicels, size of the flowers, pubescence of the siliques, and arrangement of the seeds in the mature siliques. The distributional areas of the two forms overlap considerably, although subsp. *adenophora* has in general a more westerly and southerly range and might be considered more nearly a desert ecotype. As might be expected, some intergrading occurs between the two, but the intergrading usually affects one or two characters only, the others remaining constant for one or the other of the subspecies. The third subspecies, *brevisiliqua*, is an ecotype of the *Juniperus* forests of Northern New Mexico and Arizona, and as far as I have observed does not grow with either of the other ecotypes.

KEY TO THE SUBSPECIES

Plants non-glandular.
Siliques 5-9 mm. long ..... 5c. subsp. *brevisiliqua*
Siliques 10-20 mm. long ..... 5a. subsp. *typica*
Plants glandular, at least in the inflorescence ..... 5b. subsp. *adenophora*

5a. **Descurainia obtusa** subsp. **typica** nom. nov.

(*Sophia obtusa* Greene, Leaflets Bot. **1**:96. 1904. *Sisymbrium obtusum* Nels. and Macbr. Bot. Gaz. **56**:475. 1913. *Descurainia obtusa* O. E. Schultz, loc. cit. *Sisymbrium Cumingianum* of American authors, in part, not Fisch. and Mey.)

Whole plant, including pedicels and calyces, finely canescent but non-glandular. Calyx 1-2 mm. long, the corolla equalling or only slightly exceeding it. Fruiting pedicels 6-15 mm. long, spreading 30°-45°. Siliques 10-20 mm. long, sparsely to moderately beset with stellate hairs. Seeds .5-.75 mm. long, 8-16 in each locule, distinctly uniseriate or occasionally showing a crowded biseriate arrangement.

Mountains and plateau regions of New Mexico, Arizona, Baja California and probably Northern Chihuahua and Sonora. Type: Mimbres River, in the Black Range, Grant County, New Mexico, O. B. Metcalfe 1074.

NEW MEXICO. *Grant Co.:* Mimbres River, Metcalfe 1074 (type collection, RM, US); Bear Mt., near Silver City, Wooton, July 9, 1900 (RM, US); Fort Bayard Watershed, Blumer 224 (US); Hanover Mt., Holzinger, July 29, 1911 (US); Big Burros Ranger Station, Gila Forest, Eggleston 17243 (US). *Catron Co.:* Mangas, Metcalfe 100 (US). *Santa Fe Co.:* Santa Fe, Bros. Arsene & Benedict 15927 (US). ARIZONA. *Greenlee Co.:* 33 mi. north of Clifton, Kearney & Peebles 12229 (US). *Pima Co.:* Sabino, Tuomey 115 (C). BAJA CALIFORNICA. La Encantada, Sierra San Pedro Martir, Wiggins & Demaree 4885 (DS); La Gruela, Sierra San Pedro Martir, Goldman 1250a (US).

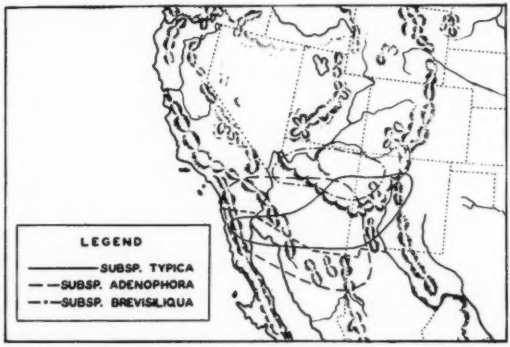
5b. **Descurainia obtusa** subsp. **adenophora** (Woot. and Standl.) comb. nov.

(*Sophia adenophora* Woot. and Standl. Contr. U. S. Nat. Herb. **16**:127. 1913. *Descurainia adenophora* O. E. Schulz, Pflanzenreich 4, Fam. **105**:321. 1924. *Sisymbrium Cumingianum* of American authors, in part, not Fisch. and Mey.)

Leaves and stems canescent, sometimes sparingly glandular. Axis of racemes moderately to rather densely glandular. Pedicels and calyx sparsely stellate-pubescent and glandular. Siliques typically glabrous but occasionally sparsely to moderately stellate-pubescent. Calyx 2-2.5 mm. long, corolla about the same length or slightly exceeding it. Fruiting pedicels 12-25 mm. long, spreading about 65° (50°-85°). Seeds .75-1 mm. long, 24-32 in each locule, biseriate but frequently so closely crowded as to appear uniseriate.

From Northwestern Chihuahua and the western borders of New Mexico through Central and Southern Arizona to the mountains of Southern California and Baja California. The type specimen, in the United States National Herbarium, was collected "at the Head and Wilson Ranch south of Mule Creek, in northwestern Grant County," New Mexico, by E. O. Wooton. July 13, 1900.

NEW MEXICO. *Catron Co.:* Frisco Creek, Mogollon Mts., Wooton, July 25, 1900 (C, US); Tularosa Creek, Wooton, July 14, 1906 (US). *Grant Co.:* Head and Wilson Ranch, Mogollon Mts., Wooton, July 13, 1900 (type, US, isotype, NMC, US). ARIZONA. *Apache Co.:* McNary, Whitehead 1599 (US). *Yavapai Co.:* Prescott, Wolf 2349 (DS, GH), Jones 273 (C, GH). CALIFORNIA. *San Bernardino Co.:* Victorville, Parish 10542 (DS). *Riverside Co.:* Kenworthy, San Jacinto Mts., Munz 5975 (RM); Strawberry Valley, San Jacinto Mts., Hall 2623 (C, DS); Idyllwild, San Jacinto Mts., Spencer 1748 (GH). *Los Angeles Co.:* Rock Creek, San Bernardino Mts., Davidson, July, 1893 (DS). *County undetermined:* Santa Rosa, Santa Rosa Mts., Munz 5906 (C). BAJA CALIFORNIA. Hansen's Ranch, Orcutt 133 (US). "Northern Lower California," Orcutt 278 (US). CHIHUAHUA. Canyon of Rio San Miguel, Hartman 649 (C, GH, US).



Map 4. Distribution of *Descurainia obtusa.*

5c. **Descurainia obtusa** subsp. **brevisiliqua** subsp. nov.

Siliquis 5-9 mm. longis, glaberrimis; pedicellis fructiferis 4-6 mm. longis, circa 45° patentibus; seminibus biseriatis, 5-14 in utroque loculo, circa .5 mm. longis; foliorum pinnis linearibus, rarius oblanceolatis.

Siliques 5-9 mm. long, glabrous, on pedicels 4-6 mm. long, spreading about 45°. Seeds biseriate, 5-14 in each locule, about .5 mm. long. Leaf-segments mostly linear.

Type, 1 mile west of the Continental Divide, near Gonzales, McKinley Co., New Mexico, Aug. 1, 1937, L. E. Detling 2375, in the herbarium of the University of Oregon.

In the *Juniperus* belts on the high plateaus from Northwestern New Mexico to Northwestern Arizona.

In the *Pinus ponderosa* forest a few miles east of Flagstaff, Arizona, I have collected specimens which clearly connect this form with subsp. *typica.* They have in general the short glabrous siliques of *breviliqua,* with distinctly biseriate seeds, but the siliques are on longer pedicels; and the plants show none of the linear leaflets of the New Mexican type.

The siliques of many of the individuals of this subspecies resemble closely

those of the southern subspecies of *Descurainia pinnata*, but the plants may be distinguished by their tall strict habit with short branches above, and by their biennial type of growth. Their stems are usually purplish, but this character is not constant.

New Mexico. *McKinley Co.:* Gonzales, Detling 2375 (type, Or, isotype, DS); Thoreau, Detling 2374 (Or), Detling 2359 (Or). Arizona. *Coconino Co.:* Flagstaff, Detling 2380 (Or), Munz 13070 (C). *Mohave Co.:* Ft. Mohave, J. G. Lemmon & Wife, April, 1884 (C).

6. *Descurainia pinnata* (Walt.) Britt. Mem. Torrey Club 5:173. 1894.

Annual plants from 10 to 70 cm. in height, commonly widely branching from the base and thus bushy, or in certain subspecies typically simple and more strict. Leaves from ovate to lanceolate or oblanceolate in general outline, 1-10 cm. long, gradually reduced in size upward, the lower ones usually bipinnate with leaflets often again pinnatifid, the upper mostly simply pinnate; the leaf-segments from broadly obovate or oblanceolate to narrowly linear. Amount of pubescence varying from sparse to densely canescent. Glands on the stems or leaves either present or absent. Corolla from bright yellow to almost white, 1-3.5 mm. long, usually equalling the calyx in the smaller flowers, surpassing it by .5 to 1 mm. in the larger ones. Fruiting pedicels 3-20 mm. long, spreading 30°-90° from the axis of the raceme or occasionally even slightly reflexed. Siliques clavate or subclavate (elliptical in 6e) or only rarely linear and then broad enough to distinguish this from species with typically linear siliques, 4-20 mm. long (2 mm. in 6e), 1-2 mm. broad. Seeds typically biseriate but at times crowded into one row, 5-20 in each locule (1-2 in 6e), elliptical, .5-1 mm. long.

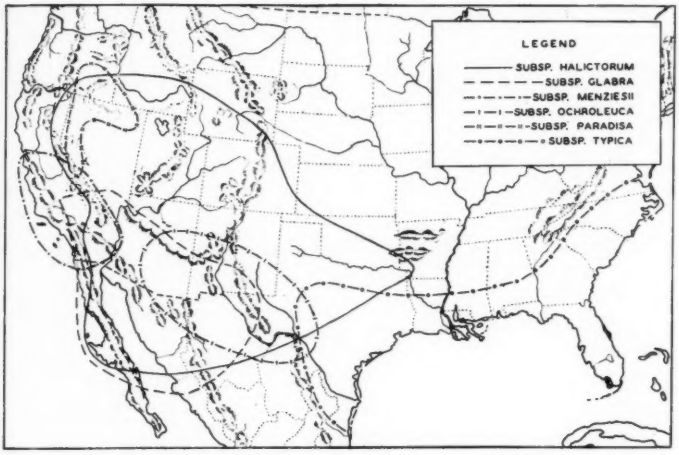
A species of wide geographical and environmental distribution and of extreme morphological variation.

Evolution within this species seems to have followed two distinct lines, giving rise to one complex of subspecies in the hot arid regions of the Southwest and another complex in the more northern cooler and frequently moister regions of the Rocky Mountains, the Pacific Northwest and Canada. The two groups can be distinguished so clearly that some authors have considered the northern one a distinct species (*D. brachycarpa* (Richards.) O. E. Schulz). However, the forms of the two groups intergrade so closely where they occur together that it is impossible to admit sufficient genetic difference to warrant such a separation.

The chief morphological differences between the two complexes of ecotypes are that the southern group is more canescent, the plants are more bushy, the pedicels and siliques more widely spreading, and the flowers smaller or paler or both. The northern types are taller and stricter, either nearly glabrous or at least not canescent, the pedicels and siliques tend to be more ascending and the flowers are mostly larger and brighter yellow.

The southern complex of subspecies of *D. pinnata* are typically inhabitants of the arid regions of the Southwest, although one of them, subsp. *typica*, extends eastward through the coastal plains of the Gulf and South Atlantic

States (Map 5). The most wide-spread population is that of subsp. *halictorum*, extending as it does from the Sierra Nevada of California to the plains of Oklahoma and Texas, and from the northern Mexican plains to Southern Idaho. This is typically a much-branched form with small whitish or pale yellow flowers, and the axis of the racemes either glandular or merely pubescent. Toward the western limits of its distribution, in Nevada and on the eastern slopes of the Sierra Nevada, its flowers tend to be somewhat larger and of a brighter yellow. In the more extremely arid regions included in its general range, namely in the deserts of Southern California, in Southern Arizona and Southwestern New Mexico, and the Sonoran desert of Mexico, this

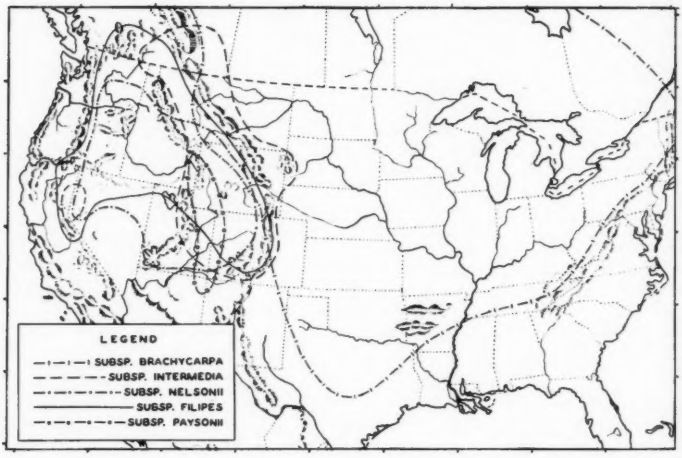


Map 5. Distribution of the southern subspecies of *Descurainia pinnata*.

subspeices gives way to subsp. *glabra*, a form with much shorter siliques, glabrous inflorescence, and usually much shorter and more rounded ultimate leaf-segments. Occupying partially the same region in New Mexico as *halictorum*, but extending eastward through the Rio Grande Valley and into Central Texas is the extremely canescent, low-branching form with short rounded leaf-lobes, pale sulphur-yellow flowers and broad siliques, subsp. *ochroleuca*. This is closely related to subsp. *typica* which extends on eastward to the Atlantic States, but which is more erect and is typically glandular in the inflorescence. The territory west of the California deserts and northward along the sandy coasts as far as San Francisco Bay is occupied by another tall strict form, characterized by unusually large bright yellow flowers and heavy broad siliques. This is subsp. *Menziesii*. Less frequently this form occurs in the San Joaquin Valley and the southern and central Sierra Nevada, where it seems to mix somewhat with the more northern members of this species. There is both a glandular and a non-glandular form of this subspecies but the two occupy the

same geographical area and identical habitats, and are apparently but local minor variations of the same thing. In the valleys of South Central Oregon and Northern Nevada and less frequently as far south as Inyo County California, is found an extremely well-marked type of low, bushy, glandular plants with very short and few-seeded siliques. This has been considered by all previous authors a distinct species, *D. paradisa* (Nels. and Kenn.) O. E. Schulz. In the southern limits of its range, however, it intergrades noticeably with subsp. *glabra*, becoming less pubescent, losing its glandulosity, and showing all intermediate lengths of silique. This fact should clearly give it a place among the subspecies of *pinnata*.

The northern complex of ecotypes is in a general way restricted to the plains regions of Canada and the North Central States, the northern Rocky Mountains, the Pacific Northwest, the northern Sierra Nevada, and the adjacent portions of Nevada and Utah (Maps 1 and 6). The eastern plains



Map 6. Distribution of the northern subspecies of *Descurainia pinnata*.

region, up to the base of the Rocky Mountains, is occupied by subsp. *brachycarpa*. In its typical form this is a tall, erect plant with large flowers, broad siliques, and glandular stems and inflorescence. In the northern Rocky Mountain area this form is superseded by another similar in most respects except that it lacks glandulosity and is more glabrous. This subspecies, *intermedia*, intergrades considerably with *brachycarpa*, as is evidenced by specimens with only a few scattered glands, or with varying degrees of pubescence. The main area of distribution of *intermedia* is in South Central Montana and the mountains of Western Wyoming and Colorado. However, what is apparently the same thing occurs again in Northern California east of the Sierra Nevada

crest and in adjacent Western Nevada. Occupying partially the same region in the northern Rockies as *intermedia*, but extending westward through the plateau country of Idaho, Washington and Oregon as far as the Cascade Range, with scattered stations in Utah and Nevada is the small-flowered, short-pedicelled, shorter- and narrower-siliqued subspecies *Nelsonii*. This is an ecotype of more arid lands, in contrast with the preceding ecotype of the cooler and moister highlands. Coinciding roughly with *Nelsonii* in geographical distribution, although centered more westerly and found in its most typical form on the plains of Eastern Washington, is subsp. *filipes*. It also extends southward in the Sierra Nevada to Central California and northward into British Columbia. Occupying an arid region along the eastern rim of the Great Basin is a fifth ecotype in this northern complex, which is to be described later in this paper as subsp. *Paysonii*.

KEY TO THE SUBSPECIES

Fruiting pedicels spreading about 75° (60°-90°); herbage mostly canescent (moderately pubescent in 6d).
- Leaf-segments blunt, ovate to oblanceolate.
  - Herbage canescent; flowers whitish to pale yellow; siliques averaging 8-10 mm. long.
    - Plants tall and strict; raceme moderately glandular ..... 6a. subsp. *typica*
    - Plants wide-branching from the base; raceme not glandular.... 6b. subsp *ochroleuca*
  - Herbage moderately pubescent, raceme glabrous; flowers small and yellow; siliques averaging about 6mm. long..... 6d. subsp. *glabra*
- Leaf-segments narrowly oblong to linear.
  - Siliques 4 mm. long or less, 2-4-seeded; plants low and bushy, glandular ..... 6e. subsp. *paradisa*
  - Siliques 5 mm. long or more, 10-30-seeded; plants usually taller, glandular or non-glandular.
    - Petals 2 mm. long or more, bright yellow; plants mostly strict ..... 6f. subsp. *Menziesii*
    - Petals mostly less than 2 mm. long, yellow or whitish; plants usually short and branched below ..... 6c. subsp. *halictorum*

Fruiting pedicels spreading about 45° (30°-70°); herbage not canescent (except in 6k).
- Stems glandular and moderately pubescent ..... 6g. subsp. *brachycarpa*
- Stems not glandular, or if glandular then otherwise only sparsely pubescent or glabrous.
  - Herbage densely canescent ..... 6k. subsp. *Paysonii*
  - Herbage sparsely pubescent.
    - Petals 1.5 mm. long or less; pedicels less than 6 mm., siliques less than 8 mm. long ..... 6i. subsp. *Nelsonii*
    - Petals 2 mm. long or more; pedicels more than 6 mm., siliques more than 8 mm. long.
      - Pedicels slender and mostly longer than the siliques; terminal leaflet usually greatly elongated; seeds frequently uniseriate ..... 6j. subsp. *filipes*
      - Pedicels usually not longer than the siliques; terminal leaflet not greatly elongated; seeds always biseriate ..... 6h. subsp. *intermedia*

6a. **Descurainia pinnata** subsp. **typica** nom. nov.

(*Erysimum pinnatum* Walt. Fl. Carol. 174. 1788. *Cardamine multifida* Pursh, Fl. Am. Sept. **2**:440. 1814. *Sisymbrium canescens* Nutt. Gen. N. Am. Pl. **2**:68. 1818. *Sisymbrium pinnatum* Greene, Bull. Cal. Acad. Sci. **2**:390. 1887. Not Barn. 1845.

Descurainia canescens Prantl, in Engl. and Prantl, Nat. Pfl. Fam. 3, Abt. **2**:192. 1892. *Sisymbrium multifidum* MacMillan, Metasp. Minn. Valley, 258. 1892. *Descurainia pinnata* Britt. loc. cit. 1894. *Sophia pinnata* Howell, Fl. N. W. Am. **1**:56. 1897. *Sophia myriophylla* Rydb. in Britton, Man. 462. 1901. Not *Sisymbrium myriophyllum* H. B. K. *Sophia millefolia* Rydb. in Britton, Man. ed. 2, 462. 1905. *Sisymbrium multifidum* subsp. canescens Thell. in Hegi, Fl. Mitteleur. 4, **1**:153. 1916. *Descurainia multifida* O. E. Schulz, Pflanzenreich 4, Fam. **105**:328. 1924. *Descurainia Menziesii* var. *villosa* O. E. Schulz, Pflanzenreich 4, Fam. **105**:329. 1924. *Descurainia multifoliata* Cory, Rhodora **38**:404. 1936.)

20-45 cm. tall, simple or with short branches below, the central axis well developed. Lower leaves bipinnate, the upper ones pinnate with pinnatifid segments, the ultimate segments obovate, obtuse. Leaves, stem, axis of the racemes, pedicels and calyces moderately to densely canescent. Stem and axis of racemes moderately glandular. Flowers whitish; calyx 1-2 mm.long, slightly exceeded by the corolla. Fruiting pedicels 6-15 mm. long, spreading 70°-90°. Siliques distinctly clavate, 5-9 mm. long, style short, stigma broadly capitate. Seeds regularly biseriate, 7-11 in each locule.

Coastal plains from the Rio Grande to North Carolina. According to Nuttall is occurs "from Virginia to Georgia," but I have seen no specimens from the first-named state. Type locality: "Carolina."

North Carolina. *New Hanover Co.:* Wilmington, Curtis, without date (PAS), Bartram & Long 900 (PAS), Bartram & Long 966 (PAS), Williamson, April 14, 1911 (PAS), Williamson, April 16, 1892 (PAS). South Carolina. *Charleston Co.:* Charleston, Rev. J. Backman, without date (PAS). Georgia. *Miller Co.:* S. Boykin, collector and date ? (PAS). *County undetermined:* "Georgia," Nuttall, without date (type of *Sisymbrium canescens*, PAS). Florida. *Duval Co.:* Jacksonville, Curtiss 6352 (C, US), Curtiss 4206 (C, DS). Texas. *Hidalgo Co.:* Mission, Hanson 324 (Col, US). *Atascosa Co.:* Campbelton, Palmer 11241 (C, RM). *Lubbock Co.:* Lubbock, Demaree 7445 (DS, GH, US), Demaree 7457 (DS, GH, US). *Victoria Co.:* Victoria, Palmer 9067 (DS). *Gonzales Co.:* Ottine Swamp, Cory 18147 (GH). *Brewster Co.:* Hot Springs, Sperry 532 (US); Tornillo Flats, Sperry 537 (US); Alpine, Newman T165 (US).

6b. **Descurainia pinnata** subsp. **ochroleuca** (Woot.) comb. nov.

(*Sophia ochroleuca* Woot. Bull. Torrey Club **25**:455. 1898. *Sisymbrium ochroleucum* K. Schum., Just, Bot. Jahresber. 26 (1898), pt. **1**:348. 1900. *Descurainia Menziesii* var. *ochroleuca* O. E. Schulz, Pflanzenreich 4, Fam. **105**:329. 1924.)

10-40 cm. tall, widely branching from the base, the central axis of the plant not so well developed as in the preceding subspecies. Lower leaves bipinnate or again pinnatifid, the lobes obovate to oblanceolate, obtuse; the upper ones pinnate or bipinnate, the ultimate lobes obovate or oblanceolate. Whole plant densely canescent, typically non-glandular. Flowers slightly smaller than in subsp. *typica*, the calyx 1.5-2 mm. long, usually tipped with rose, about equalling the whitish corolla. Fruiting pedicels about 6 (3-10) mm. long, spreading about 45° (40°-80°). Siliques broadly clavate, 9-13 mm. long, style very short or obsolete, stigma mostly truncate. Seeds distinctly biseriate, 7-12 in each locule, about .75 mm. long.

On the Lower Sonoran plains of Southern New Mexico, Southeastern Arizona, Northern Sonora and Chihuahua and Western Texas. The type collection is from the Mesilla Valley, New Mexico, by J. D. Tinsley. It is

closely related to subsp. *halictorum* which occupies this same territory, and with which it intergrades closely.

ARIZONA. *Pima Co.:* Rillito Creek, Tucson, Bartram 118 (US). *Pinal Co.:* Sacaton, Peebles & Harrison 879 (US), Harrison 8380 (US). *Apache Co.:* Hunt, Nodwell 7080 (US). NEW MEXICO. *Dona Ana Co.:* Mesilla Valley, Wooton, May, 1905 (US), Wooton, May, 1903 (C, Col), Wooton & Standley 3243 (DS, OSC); Mesilla Park, Cockerell, Feb. 25, 1900 (Col). *Grant Co.:* Mangas Springs, Metcalfe 20 (C, GH, RM, US). *Valencia Co.:* Laguna, Cleveland, July 15, 1885 (C). TEXAS. *El Paso Co.:* El Paso, Stearns 134 (US). *Reeves Co.:* Pecos, Reed 2832 (US). *Kinney Co.:* Fort Clark, Mearns 1266 (US), Mearns 1255 (US). *Lubbock Co.:* Lubbock, Demaree 7458 (DS, US). CHIHUAHUA. Santa Eulalia Plains, Wilkinson, April 2, 1885 (C).

6c. **Descurainia pinnata** subsp. **halictorum** (Cockerell) comb. nov.

(*Sophia halictorum* Cockerell, Bull Torrey Club **25**:460. 1898. *Sisymbrium halictorum* K. Schum., Just, Bot. Jahresber. 26 (1898), p. **1**:348. 1900. *Sophia andrenarum Cockerell*, Bull. Torrey Club **28**:48. 1901. *Sophia andrenarum* var. *osmiarum* Cockerell, Bull. Torrey Club **28**:48. 1901. *Descurainia halictorum* O. E. Schulz, Pflanzenreich 4, Fam. **105**:329. 1924. *Descurainia halictorum* var. *andrenarum* O. E. Schulz, Pflanzenreich 4, Fam. **105**:330. 1924. *Descurainia halictorum* var. *osmiarum* O. E. Schulz, Pflanzenreich 4, Fam. **105**:330. 1924. *Descurainia andrenarum* Cory, Rhodora **38**:406. 1936.)

15-50 cm. tall, the smaller plants usually simple, the larger ones branching from near the base. Leaves relatively small, 1-6 (typically about 2.5) cm. long, mostly oblanceolate to lanceolate in outline, the upper ones simply pinnate with 2-8 pairs of linear entire pinnae or these less commonly again pinnatifid; the lower leaves pinnate or bipinnate, the ultimate segments from ovate to linear. Leaves and lower portion of stem densely to moderately canescent, the axis of the racemes, pedicels and calyces varying from canescent to almost glabrous. Stems and inflorescence usually, though not always, glandular. Flowers relatively small, the calyx 1-2 mm. long, frequently rose-colored, corolla slightly longer, whitish or yellow. Fruiting pedicels 8-12 mm. long, spreading 65°-90° (typically about 70°). Siliques clavate 5-10 mm. long, style short and blunt. Seeds biseriate, 8-20 in each locule, .75-1 mm. long.

This is the most widely distributed subspecies of the southern complex of *D. pinnata*, and the one which most readily adapts itself to varying ecological conditions. For these reasons it seems altogether plausible to consider it the most primitive of these southern types. Its range extends in general from the slopes of the Sierra Nevada and the Cascade Range of Southern Oregon eastward through the Great Basin and the southern Rocky Mountains to Arkansas and Central Texas, and southward into Chihuahua, Sonora and Baja California. It is conspicuously absent west of the Sierra Nevada and the Cascade Range. In some localities within this general area it is partially or largely superseded by other ecotypes. The typical form of this subspecies has much elongated leaf-segments and small whitish flowers. In the more western portions of its range, however, a considerable number of individuals occur in which the flowers are quite yellow and conspicuously larger, and in which the leaf-segments are shorter. Possibly this may be due to the influence of other subspecies on its western border, such as *Menziesii* or, in less likelihood, *glabra*. The distinctively yellow color of the flowers, however, is not uncom-

mon in the more central and eastern portions of its range. Cockerell gave specific recognition to the non-glandular form of this subspecies *(Sophia andrenarum)*, but an examination of most colonies of the plants reveals both forms growing together and with varying degrees of glandulosity. The type locality of the two species and the one variety published by Cockerell, which are included here, is the Mesilla Valley, New Mexico.

NEW MEXICO. *Dona Ana Co.:* Mesilla Park, Cockerell, 1900 (NY, US), Cockerell, Feb. 25, 1900 (Col); Mesilla Valley, Wooton, May 3, 1899 (C, Col, RM); Mesa west of the Organ Mts., Wooton, May 1903 (C, RM). *San Miguel Co.:* Las Vegas, Cockerell, May 23, 1901 (C, RM, US). *Bernalillo Co.:* Albuquerque, Castetter, April 30, 1929 (RM). *Santa Fe Co.:* Santa Fe, A. A. & E. G. Heller 3554 (US), Cockerell, 1895 (NMC). *McKinley Co.:* Gonzales, Detling 2376 (Or). *Union Co.:* Sierra Grande, Standley 6200 (US). *Sandoval Co.:* Ritos de los Frijoles, Eggleston 20029 (US). *San Juan Co.:* Aztec, Baker 358 (GH, RM, US). *Socorro Co.:* Magdalena, Herrick 835 (US). *Lincoln Co.:* Gray, Skehan 85 (C, GH, RM, US). *Grant Co.:* Silver City, Eastwood 8263 (GH, US). *Catron Co.:* Beaverhead, Eggleston 20447 (US). TEXAS. *El Paso Co.:* El Paso, Hanson 403 (US), Jones 3711 (C, US); Ysleta, Rehn & Viereck, April 2, 1902 (RM). *Tarrant Co.:* "Tarrant Co.," Ruth 347 (C). *Brewster Co.:* Alpine, Newman T166 (US). OKLAHOMA. *Comanche Co.:* Fort Sill, Clemens 11604 (Mo.). *Creek Co.:* Sapulpa, Bush 1015 (Mo). *Kingfisher Co.:* Kingfisher, Diehl, May 10, 1902 (C). *Alfalfa Co.:* Ingersoll, Bush, May 6, 1902 (GH). *Texas Co.:* Camp, Stevens 426 (GH). *Payne Co.:* Ripley, Clark 291 (ISB). ARKANSAS. *Hempstead Co.:* Fulton, Bush 1346 (GH). ARIZONA. *Pima Co.:* Sells, Fosberg 7452 (C). *Coconino Co.:* Flagstaff, Hanson 735 (RM); Grand Canyon, Macbride & Payson 354 (GH, RM). *Navajo Co.:* Keams Canyon, Peebles 13401 (US). *Santa Cruz Co.:* Nogales, Tidestrom 702 (US). CALIFORNIA. *San Bernardino Co.:* Baldwin Lake, Peirson 10673 (C, DS); Mill Creek, San Bernardino Mts., Leiberg 3277 (Or). *Nevada Co.:* Donner Lake, Heller 6937 (C, DS, Or, RM, US). *Siskiyou Co.:* Yreka, Butler 126 (C); Klamath River, Butler 727 (C); Mt. Shasta, Brown 548 (US). *Riverside Co.:* Seven Palms, Ewan 7031 (Th). *San Diego Co.:* Boulevard, Laguna Mts., McGregor 121 (DS). *Mono Co.:* Leevining Grade, Keck 502 (C, DS). *Los Angeles Co.:* San Clemente Id., Munz 6740 (C). NEVADA. *Lincoln Co.:* Calientes, Meadow Valley Wash, Goodding 926 (C, DS, RM, US), Goodding 2167 (C, GH, RM). *Washoe Co.:* Pyramid Lake, Kennedy 2030 (DS). *Esmeralda Co.:* Goldfield, Heller 10413 (DS, US). *Clark Co.:* Lee Canyon, Charleston Mts., Heller 11041 (C, DS, US). *Nye Co.:* Currant, Bentley, June 6, 1916 (DS, RM). *Humboldt Co.:* Paradise Valley, Train 12 (US). UTAH. *Cache Co.:* Logan-Providence Ditch, Smith 1825 (RM). *Washington Co.:* St. George, Jones 1612 (C, US). *Salt Lake Co.:* City Creek Canyon, H. M., May 13, 1891 (T). *Uinta Co.:* Skull Pass Quarry, Graham 7624 (US). COLORADO. *Chaffee Co.:* Salida, Eggleston 6680 (US). *Montrose Co.:* Paradox, Walker 100 (RM, US). *Huerfano Co.:* Walsenburg, Rydberg & Vreeland 6171 (RM). *Costilla Co.:* San Luis, Ramaley 14866 (Or). *Alamosa Co.:* Alamosa, Schmoll 1000 (RM). *Ouray Co.:* Ridgway, E. B. & L. B. Payson 3853 (RM). *Weld Co.:* Grover, Johnston 181 (RM). *Gunnison Co.:* Sapinero, Wheeler 472 (Col, RM). *Larimer Co.:* Plains of Larimer County, Patterson 640 (RM). *Saguache Co.:* San Luis Valley, Brandegee, 1875 (C). WYOMING. *Sweetwater Co.:* Point of Rocks, Nelson 7082 (Col, Or, RM, US). *Lincoln Co.:* Kemmerer, Nelson 9032 (RM). *Sublette Co.:* Big Piney, E. B. & L. B. Payson 4367 (RM); Boulder, Detling 2291 (Or). *Natrona Co.:* Bates Creek, Goodding 195 (GH, RM, US). IDAHO. *Twin Falls Co.:* "Twin Falls County," Nelson & Macbride 1704 (RM, US). *County undetermined:* Snake Plains of Idaho, Palmer 344 (US). OREGON. *Lake Co.:* Paisley, Henderson, June 21, 1927 (Or). *Harney Co.:* 10 miles north of Denio, Peck 19077 (W). BAJA CALIFORNIA. Guadalupe Id., Howell 8295 (GH, US); Nachoguero Valley, Schoenfeldt 3411 (US); Cedros Id., Palmer 726 (US). SONORA. San Bernardo, Rio Mayo, Gentry 1303 (GH). CHIHUAHUA. St. Diego, Hartman 644 (C, GH, US).

6d. **Descurainia pinnata** subsp. **glabra** (Woot. and Standl.) comb. nov.

(*Sophia glabra* Woot. and Standl. Contr. U. S. Nat. Herb. **16**:127. 1913.)

Stems commonly branching from near the base, 10-49 cm. tall. Leaves bipinnate, the ultimate segments ovate or oblong, not elongated. Leaves and lower part of stem lightly canescent, less so than in subsp. *halictorum*, the rest of the plant glabrous, non-glandular. Flowers small, the yellow or rose-colored calyx .75-1.5 mm. long, only slightly exceeded by the yellow corolla. Fruiting pedicels 4-12 mm. long, spreading 60°-90°. Siliques clavate, 5-8 mm. long, style very short or obsolete. Seeds biseriate, 8-12 in each locule, about .5 mm. long.

This form largely displaces subsp. *halictorum* in the more extreme desert regions of Southern California, Arizona and New Mexico, and extends southward into Baja California, Sonora and Chihuahua, reaching its highest development in the Mojave Desert and adjacent Arizona. A striking adaptation to its desert environment, revealed by experimental cultures, is its unusually short cycle of growth and reproduction. Cultures of this subspecies, planted at the same time as cultures of subsp. *halictorum* from various localities and grown under identical conditions of light, moisture and soil, matured seeds from three to four weeks earlier than *halictorum*. This precocity was approached only by cultures of subsp. *Nelsonii* from Western Wyoming, which, incidentally, is another aridland ecotype.

The type, collected by Wooton and Standley in the Organ Mountains, New Mexico, on March 21, 1907, is deposited in the United States National Herbarium.

New Mexico. *Dona Ana Co.:* Organ Mts., Wooton & Standley, March 21, 1907 (type, US), Cockerell, April 24, 1898 (NMC); Van Patten's, Organ Mts., Wooton, April 25, 1895 (US); Bishop's Cap, Organ Mts., Wooton, March 30, 1905 (US). *Eddy Co.:* Carlsbad Caverns, Convis 44 (RM). Arizona. *Pima Co.:* Tucson, Loyd, Feb. 27, 1907 (GH), Toumey 69a (US). *Maricopa Co.:* White Tank Mts., Gillespie 8870 (DS, US); Salt River Mts., Gillespie 8783 (C, DS, US); Wickenburg Mts., Gillespie 5341 (C, DS). *Santa Cruz Co.:* Nogales, Abrams 13130 (DS). *Pinal Co.:* Santan Mts., Gillespie 8756 (C, DS, US). *Coconino Co.:* Flagstaff, MacDougal 133 (C, GH, US). *Cochise Co.:* Rucker, Jones, May 22, 1922 (C). *Yavapai Co.:* Prescott, Nelson 10229 (C). *Mohave Co.:* Ft. Mojave, Robbins 8414 (Col. Or). Nevada. *Clark Co.:* Goodsprings, Brandegee, May, 1915 (C); Erie, Tidestrom 8888 (US). California. *Kern Co.:* Mojave, Heller 7763 (C, DS, GH, US); Weldon, S. Fk. Valley, Voegelin 88 (C); Bakersfield, Benson 3107 (DS, Th). *Inyo Co.:* Wyman Canyon, White Mts., Ferris & Bacigalupi 8050 (C, DS); Silver Canyon, White Mts., Heller 8218 (DS, GH, US); Maturango Peak, Argus Mts., Ferris 7841 (C, DS); Black Canyon, White Mts., Duran 534 (C, DS, Or, RM, US); Darwin Falls, Ferris 7419 (DS, US). *San Bernardino Co.:* Bonanza, Providence Mts., Munz & Harwood 3439 (C, DS, US); 20 miles north of Box "S" Ranch, Munz 12419 (C). *Riverside Co.:* Palm Canyon, Johnston 1070 (DS, US); Chuckawalla Bench, Hall 5887 (C); Cottonwood Springs, Ferris & Rossbach 9538 (Or). *San Diego Co.:* San Felipe Gap, Brandegee, April 6, 1901 (C). *Santa Barbara Co.:* Cuyama Valley, Ferris 9144 (DS). Baja California. Junction of El Marmol and San Fernando Roads, Wiggins 4348 (C, DS); Cedros Id., Rose 16168 (GH, US); Los Angeles Bay, Palmer 579 (GH, US); Santa Agueda, Palmer 238 (GH, US); San Quentin Bay, Palmer 725 (US). Sonora. Santa Ana, Abrams 13252 (DS); 15 miles north of Magdalena, Fosberg 7441 (C, DS); Canyon of Magdalena River, 9 miles from Imuris, Ferris 8795

(DS, US); Torres, Wiggins 6274 (DS, US); Queriego, Wiggins 6445 (DS, US). CHIHUAHUA. St. Diego, Hartman 818 (GH). SINALOA. San Blas, Jones, Feb. 2, 1927 (C, RM), Rose, Standley & Russell 13414 (GH, US).

6e. **Descurainia pinnata** subsp. **paradisa** (Nels. and Kenn.) comb. nov.

(*Sophia paradisa* Nels. and Kenn. Proc. Biol. Soc. Wash. **19**:155. 1906. *Sisymbrium paradisum* Nels. and Macbr. Bot. Gaz. **56**:475. 1913. *Descurainia paradisa* O. E. Schulz, Pflanzenreich 4, Fam. **105**:331. 1924.)

Annual plants 10-25 cm. tall, widely branching from the base, the stems frequently purple. Leaves not more than 3 cm. long, the lower ones commonly pinnate with the segments pinnatifid, the ultimate lobes short and obtuse, the upper either similar or more commonly simply pinnate with 2-4 pairs of narrowly lanceolate or linear pinnae, their margins entire or serrate. Leaves and stems canescent, the axis of the racemes moderately stellate-pubescent and glandular. Flowers pale yellow or whitish, very small, the calyx 1 mm. long or less, the corolla 1-1.5 mm. long. Fruiting pedicels 3-6 mm. long, spreading about 45°. Silique oblong-elliptical, 2-4 mm. long. Seeds 1-2 in each locule.

South Central Oregon and Northern and Western Nevada, southward to Inyo County, California. The type, in the Rocky Mountain Herbarium at the University of Wyoming, was collected by Kennedy in Paradise Valley, Nevada.

This is a strikingly well-marked subspecies, which in its southern limits intergrades in pubescence, glandulosity, length of siliques and number of seeds with subsp. *glabra*.

OREGON. *Deschutes Co.:* Millican, Peck 18905 (W). *Lake Co.:* Wagontire, Peck 19414 (W); Plush, Peck 19501 (W); Paulina Marsh, Peck 15699 (DS, W); Desert Well, Leiberg 389 (C, DS, US). *Harney Co.:* Spring's Ranch, Silver Creek, Henderson, May 30, 1927 (Or); Silver Creek Valley, Peck 18925 (Th); Steens Mts., Leach, June, 1927 (Th). NEVADA. *Humboldt Co.:* Paradise Valley, Kennedy 1059 (type, RM, isotypes, C, DS). *Washoe Co.:* Wadsworth, Heller 9603 (DS, US); Truckee Pass, Kennedy 1321 (C, US); Reno, Hillman, 1890 (US). CALIFORNIA. *Inyo Co.:* Foothills west of Bishop, Heller 8363 (C, DS, GH, US).

6f. **Descurainia pinnata** subsp. **Menziesii** (DC.) comb. nov.

(*Cardamine Menziesii* DC. Syst. **2**:267. 1821. *Nasturtium Menziesii* Spreng. Syst. Veg. **2**:883. 1825. *Sisymbrium canescens* var. *californicum* T. and G. Fl. N. Am. **1**:92. 1838. *Sophia californica* Rydb. Bull. Torrey Club **29**:238. 1902, as to synonymy. *Sisymbrium incisum* var. *californicum* Blankinship, Mont. Agric. Coll. Sci. Studies, Bot. **1**:60. 1905, as to synonymy. *Descurainia Menziesii* O. E. Schulz, Pflanzenreich 4, Fam. **105**:328. 1924. *Descurainia Menziesii* var. *glandulosa* O. E. Schulz, Pflanzenreich 4, Fam. **105**:329. 1924.)

Plants 10-60 cm. tall, simple or sometimes short-branched, but the central axis well developed. Lower leaves bipinnate or again pinnatifid, the ultimate lobes mostly obovate and obtuse, the upper leaves pinnate to bipinnate, the ultimate lobes oblanceolate to linear. Leaves densely pubescent; stem and inflorescence from moderately pubescent to practically glabrous and either glandular or non-glandular. Flowers bright yellow; calyx 1.5-2.5 mm. long, slight-

ly exceeded by the corolla. Fruiting pedicels 5-10 mm. long, spreading 45°-90° (commonly about 80°). Siliques clavate, 5-12 (or 15) mm. long. Seeds biseriate, 6-10 in each locule, .75-1 mm. long.

Throughout Southern California; most common in sandy soil along the coast from San Diego to Contra Costa County where it is the only Descurainia found, and in the San Joaquin Valley, but extending into the southern Sierra Nevada and the Mojave and Colorado Deserts.

This subspecies may be distinguished from subsp. *halictorum* by its stricter habit, much larger flowers, and relatively broader leaf-segments, and from subsp. *typica* by its greener appeaarnce and brighter and larger flowers. O. E. Schulz considers the glandular form of this a distinct variety *(glandulosa)*. However, as frequently happens in this species, this character breaks down as one of taxonomic value when a large number of individuals is examined.

CALIFORNIA. *Monterey Co.:* Pinnacles, Ferris 1684 (DS); King City, Keck & Clausen 3053 (DS). *Alameda Co.:* Arroyo Mocho, Bacigalupi 1516 (DS). *Contra Costa Co.:* Antioch, Rattan, 1879 (DS). *San Joaquin Co.:* Manteca, Stanford 797 (DS, US). *Stanislaus Co.:* Arroyo del Puerto, Mt. Hamilton Range, C. W. & H. K. Sharsmith 1672 (C). *Santa Clara Co.:* San Antonio Valley, Mt. Hamilton Range, C. W. & H. K. Sharsmith 1690 (C), C. W. & H. K. Sharsmith 1468 (C); Stanford University, Dudley, April 11, 1894 (DS). *Mariposa Co.:* Yosemite Valley, Blasdale, May 31, 1895 (C). *San Luis Obispo Co.:* Pozo, Ferris 9083 (C, DS). *Santa Barbara Co.:* Cuyama Valley, Munz ½3617 (C, DS); Santa Barbara, Elmer 3878 (type collection of *D. Menziesii* var. *glandulosa*, DS, US); Surf, Ferris 7544 (C, DS); Pelican Bay, Santa Cruz Id., Abrams & Wiggins 56 (C, DS), Clokey 518 (US). *Los Angeles Co.:* Santa Susanna Mts., Brewer 205 (C, DS, US); San Fernando Valley, Brewer 197 (C, US); Ballena Harbor, Abrams 1206 (DS, RM); Pasadena, Grant E-1228 (RM). *San Diego Co.:* San Felipe Creek, Wiggins 2026 (DS); La Jolla, Parks 0387 (C, US). *Imperial Co.:* El Centro, McGregor 928 (DS). *Riverside Co.:* Palm Canyon, Munz, Street & Williams 2305 (DS); Fairmount Hill, Riverside, Hall 70 (C). *San Bernardino Co.:* Needles, Parish 9633 (DS); San Bernardino Valley, Parish 7072 (Or); Bear Valley, San Bernardino Mts., Parish 3162 (C, US); San Bernardino, Parish 4632 (DS). *Kern Co.:* Fort Tejon, Abrams 11787 (DS); Tehachapi, Davy 2169 (C). *Ventura Co.:* Cuddy Canyon, Mt. Pinos, Dudley & Lamb 4524 (DS, US); Mt. Pinos, Hall 6437 (C); Point Mogu, Santa Monica Mts., Wheeler 503 (DS). *Orange Co.:* Santiago Canyon, Geis 530 (DS). *Inyo Co.:* Surprise Canyon, Panamint Mts., Ferris 7953 (C, DS). BAJA CALIFORNIA. Guadalupe Id., Brandegee, March 20, 1897 (C).

6g. **Descurainia pinnata** subsp. **brachycarpa** (Richards.) comb. nov.

(*Sisymbrium brachycarpum* Richards. in Franklin, 1st. Journ., ed. 1, App. 744 (reprint, p. 16). 1823. *Sisymbrium canescens* var. *brachycarpum* S. Wats. Bibl. Index, 69. 1878. *Hesperis brachycarpa* O. Ktze. Rev. Gen. Pl. **2**:934. 1891. *Sophia pinnata* var. *brachycarpa* Farwell, Ann. Rep. Mich. Acad. Sci. **2**:49. 1901. *Sophia brachycarpa* Rydb., in Britt. Man. 462. 1901. *Sophia magna* Rydb. Bull. Torrey Club **34**:436. 1907. *Sisymbrium multifidum* subsp. *brachycarpum* Thell., in Hegi, Fl. Mitteleur. 4, **1**:153. 1916. *Descurainia longepedicellata* f. *magna* O. E. Schulz, Pflanzenreich 4, Fam. **105**:325. 1924. *Descurainia brachycarpa* O. E. Schulz, Pflanzenreich 4, Fam. **105**:325. 1924. *Descurainia pinnata* f. *simplex* O. E. Schulz, Pflanzenreich 4, Fam. **105**:328. 1924. *Sisymbrium pinnatum* var. *brachycarpon* Jepson, Fl. Calif. **2**:46. 1936.)

Annual plants 20-70 cm. tall, typically simple but occasionally branching from the base or above. Leaves dark green, from simply pinnate to bipinnate

or the lower ones often again pinnatifid, the segments of the upper ones mostly linear, those of the lower ovate to oblanceolate or linear. Leaves and stems from moderately to rather densely pubescent but not canescent, glandular. Flowers relatively large and conspicuous, yellow, the calyx 1.5-2.5 mm. long, exceeded about .5 mm. by the corolla. Fruiting pedicels 8-16 mm. long, spreading typically about 45°, though sometimes more wide-spreading. Siliques clavate, 5-10 (or 12) mm. long, standing more nearly erect than the pedicels. Seeds biseriate, though sometimes closely crowded, 5-10 in each locule, about 1 mm. long.

In the Great Plains region from Great Slave Lake southward to the Arkansas River and occasionally as far south as Central Texas, and from the eastern slopes of the Rocky Mountains to the Ohio Valley, New England and Quebec. Type collected by Richardson between Hudson Bay and Great Slave Lake.

Rydberg's *Sophia magna* is an unusually large and vigorous form of this with fruiting pedicels 12-20 mm. long and siliques11-15 mm. long.

MACKENZIE TERR. Fort Resolution, Preble 221 (US); "America Septentrionalis," Richardson (photograph of type, BM). ALBERTA. Calgary, Willing, May 13, 1905 (S); Banff, Macoun, July 29, 1891 (T); Spring Coulee, Rosedale, Moodie 1000 (GH, Or); Meeting Creek, Brinkman 2788 (US). SASKATCHEWAN. Saskatoon, Fraser, July 4, 1935 (S); Swift Current, Budd 138 (S); Crane Lake, Macoun, June 30, 1894 (GH). MANITOBA. Western Plains, Macoun, August 4, 1872 (McG); Lake Winnipeg Valley, Bourgeau, 1857 (GH). ONTARIO. Great Cloche Id., Fernald & Pease 3322 (GH, T); Georgian Bay, Jeffrey & Stebbins 127 (GH, T); Point Pelee, Macoun, May 27, 1901 (GH, T). QUEBEC. LaMadeleine, Rousseau, July 9, 1928 (GH); River Ste. Anne des Monts, Collins & Fernald, August 3-17, 1905 (GH). NEW HAMPSHIRE. *County undetermined:* White Mts., Flint 168 (NE). VERMONT. *Chittenden Co.:* Garden Id., Lake Champlain, Brainerd, July, 1892 (GH). *Franklin Co.:* Hog Back Id., Lake Champlain, Flynn, July 22, 1900 (NE). NEW YORK. *Essex Co.:* Crown Point, Eggleston 2552 (GH). *Onondaga Co.:* Syracuse, Pollard, May 15, 1903 (US). OHIO. *Erie Co.:* Sandusky, Kellerman, May 31, 1903 (GH). KENTUCKY. *Fayette Co.:* Lexington, Short, 1835 (GH). TENNESSEE. *Knox Co.:* Knoxville, Ruth 346 (GH). INDIANA. *Lake Co.:* Tolleston, Umbach, May 12, 1900 (C). *Lawrence Co.:* between Avoca and Oolitic, Kriebel 1658 (GH). ILLINOIS. *St. Clair Co.:* E. St. Louis, Eggert, May 1, 1879 (Mo, RM). *Peoria Co.:* Princeville, Chase 542 (Mo, RM). *Pike Co.:* Shepherd, Davis 2472 (Mo.) MICHIGAN. *Delta Co.:* Burnt Bluff, Fernald & Pease 3323 (GH, T). *Wayne Co.:* Belle Isle, Farwell 1721 (GH). WISCONSIN. *Brown Co.:* Benderville, Schuette, June 9, 1901 (GH). MINNESOTA. *Hennepin Co.:* Fort Snelling, Mearns, June 1, 1891 (GH). NORTH DAKOTA. *Benson Co.:* Leeds, Lunell, June 25, 1901 (GH, RM). *Traill Co.:* Belmont, Leiberg, May, 1885 (Or). *Billings Co.:* Medora, Waldron 2299 (RM). SOUTH DAKOTA. *Yankton Co.:* Yankton, Thornber, June 22, 1895 (RM). *Pennington Co.:* Wall, Palmer 37283 (GH). IOWA. *Fayette Co.:* Fayette, Fink, May, 1894 (GH). *Emmet Co.:* Armstrong, Cratty, May 26, 1897 (GH). MISSOURI. *St. Charles Co.:* Orchard Farm, Drouet 1334 (C). *Boone Co.:* Claysville, Drouet 1368 (GH). ARKANSAS. *Miller Co.:* "Miller County," Bush 1444 (GH). *Pulaski Co.:* Little Rock, Hasse, May, 1886 (DS). TEXAS. *Tom Green Co.:* Knickerbocker Ranch, Dove Creek, Tweedy, May, 1880 (US). *Gillespie Co.:* Crab-Apple, Jermy 240 (US). *Dallas Co.:* "Dallas County," Reverchon 2729 (GH). OKLAHOMA. *Alfalfa Co.:* Ingersoll, Bush 1506 (Mo). KANSAS. *Riley Co.:* "Riley County," Norton 615 (GH, RM). NEBRASKA. *Franklin Co.:* Franklin, Hapeman, May 30, 1933 (C, ISB). *Webster Co.:* Red Cloud, Bates 2830 (GH). COLORADO. *Boulder Co.:* Mouth of Boulder Canyon, Ramaley 699 (Col. RM); Boulder, Ramaley 15971 (Or). *Huerfano Co.:* La Veta, Rydberg

& Vreeland 6172 (RM), Rydberg & Vreeland 6163 (type of *Sophia magna*, NY, isotype, RM), Rydberg & Vreeland 6162 (NY). *Denver Co.:* Plains near Denver, Rydberg & Vreeland 6164 (NY). *Lake Co.:* Evans, Johnston 622 (RM). WYOMING. *Albany Co.:* Laramie, Nelson 1422 (RM). *Uinta Co.:* Evanston, Nelson 4529 (RM). MONTANA. *Gallatin Co.:* Bozeman, Blankinship, June 12, 1905 (C), Jones, May 20, 1901 (GH). *Powell Co.:* Deer Lodge Valley, Anderson, Oct., 1888 (US). *Glacier Co.:* Glacier Park Sta., Standley 17791 (US).

6h. **Descurainia pinnata** subsp. **intermedia** (Rydb.) comb. nov.

(*Sophia intermedia* Rydb. Mem. N. Y. Bot. Gard. **1**:184. 1900. *Descurainia intermedia* Daniels, Univ. Mo. Studies, Sci. ser. **1**:289 (reprint p. 147). 1907. *Sisymbrium brachycarpon* var. *intermedium* Macbr. Rhodora **17**:141. 1915, as to synonymy only. *Sisymbrium intermedium* Garrett, Spring Fl. Wasatch Reg., ed. 3, 65. 1927.)

Plants 20-65 cm. tall, erect or spreading. Leaves pinnate to bipinnate or the lower ones again pinnatifid, the segments of the upper leaves mostly linear, those of the lower from linear to obovate. Leaves glabrous or the lower ones sparsely pubescent; stems mostly sparsely to moderately pubescent below and glabrous above. Glands typically absent, although rarely, on plants seeming to connect with subsp. *brachycarpa*, a few may be present on the raceme. Flowers yellow and conspicuous, calyx 1.5-2.5 mm. long, exceeded about .5 mm. by the corolla. Fruiting pedicels 6-12 mm. long, spreading 45°-70°. Siliques clavate or more rarely broadly linear, 8-12 mm. long, standing more nearly erect than the pedicels. Seeds biseriate, although at times closely crowded so as to appear uniseriate, 5-13 in each locule, about 1 mm. long.

In the central Rocky Mountain area from Southern British Columbia and Alberta to Southern Colorado, and in a limited area in Northeastern California east of the Sierra Nevada and in adjacent Western Nevada. An inhabitant of cooler and more moist situations than the preceding subspecies, to which it is very closely related.

The specimens cited by Rydberg in his publication of *Sophia intermedia* are all, as far as I have seen, of this Rocky Mountain ecotype, and his description coincides almost exactly with this subspecies as I have here delimited it. However, he was in error in assuming that all the plants as far east as the Missouri River from Indian Territory (Oklahoma) to Saskatchewan belonged here. All the specimens I have seen from the plains region have been subsp. *brachycarpa*. Macbride, in his treatment of "*Sisymbrium brachycarpon* and allies" (Rhodora 17:138-141. 1915), evidently misunderstood Rydberg's conception of *intermedia*. He describes it as a permanently pubescent form, and follows this by the citation of Gooding's no. 195 from Bates Creek, Natrona County, Wyoming, as the type, a specimen which was not cited by Rydberg at all and which is actually subsp. *halictorum*. Other specimens from Nevada, cited by Macbride as *intermedia*, are also subsp. *halictorum*, while still others from Nevada and from Idaho are subsp. *filpes*.

ALBERTA. Medicine Hat, Macoun 3087 (GH, US); Kananaskis, Macoun, June 24, 1885 (GH). BRITISH COLUMBIA. International Boundary, between Kettle and Columbia Rivers, Macoun, June 25, 1902 (GH). MONTANA. *Gallatin Co.:* Bridger

Mts., Rydberg & Bessey 4199 (NY, US), Rydberg & Bessey 4200 (GH, NY, RM, US); Bozeman, Moore, May 23, 1900 (C, RM). *Madison Co.: Old Hollowtop*, near Pony, Rydberg & Bessey 4197 (RM, US). *Silver Bow Co.:* Melrose, Shear 3222 (NY). SOUTH DAKOTA. *Lawrence Co.:* Spearfish Canyon, Black Hills, Murdoch 4111 (GH). WYOMING. *Sheridan Co.:* Sheridan, Sharp 126 (RM). *Albany Co.:* Laramie, Macbride, June, 1913 (C, RM). *Crook Co.:* "Crook County," Ownbey 623 (RM). *Yellowstone Nat'l. Park:* Table Mt., Nelson 1349 (RM); Mammoth Hot Springs, Mearns 1161 (US). COLORADO. *Montezuma Co.:* Mancos, Baker, Earle & Tracy 86 (C, DS, GH, RM, US). *Conejos Co.:* Los Pinos, Baker 359 (RM, US). *Boulder Co.:* Boulder, Archibald, May, 1900 (Col, RM). *Weld Co.:* St. Vrain Creek, Dodds 1870 (Col, RM). *Montrose Co.:* Uncompahgre River, south of Montrose, Detling 2349 (Or); Cimarron, Baker 64 (RM). UTAH. *Salt Lake Co.:* Magna, Jones 114 (GH); Salt Lake City, Garrett, May, 1903 (GH). *Cache Co.:* Logan, Cronquist 458 (ISB). *Sevier Co.:* Wasatch Mts., Eggleston 10334 (US), Eggleston 10339 (US). NEVADA. *Washoe Co.:* Divide between Truckee Valley and Spanish Springs, Kennedy 1964 (RM); The Willows, Pyramid Lake, Kennedy 1981 (DS, GH); Peavine Mt., Heller 9771 (DS); Truckee Pass, Kennedy 1320 (C, US). *Ormsby Co.:* Carson City, Steinmetz, 1900 (DS), Anderson 153 (GH). CALIFORNIA. *Nevada Co.:* Hobart Mills, Drew, May 20 - June 6, 1925 (DS). *Lassen Co.:* Susanville, D. K. Gillespie 9325 (DS).

6i. **Descurainia pinnata** subsp. **Nelsonii** (Rydb.) comb. nov.

(*Sophia Nelsonii* Rydb. Bull. Torrey Club **34**:436. 1907. *Descurainia brachycarpa* var. *Nelsonii* O. E. Schulz, Pflanzenreich 4, Fam. **105**:326. 1924. *Descurainia halictorum* var. *osmiarum* f. *brachypoda* O. E. Schulz, Pflanzenreich 4, Fam. **105**:330. 1924.)

Erect annual plants 10-50 cm. or rarely as much as 75 cm. tall, simple or branching above. Leaves dark green, not over 4 cm. long, the upper ones simply pinnate with linear divisions, the latter sometimes with a few teeth, the lower ones pinnate to bipinnate, the segments from obovate to linear. Lower leaves and stem from sparsely to moderately pubescent, upper leaves, stems and racemes glabrous or rarely sparsely pubescent; non-glandular. Flowers yellow, small; calyx about 1 mm. long, corolla about 1.5 mm. long. Fruiting pedicels 4-6 (rately 8) mm. long, spreading about 45° (40°-70°). Siliques clavate or less commonly broadly linear, 4-8 (or 10) mm. long, mostly straight, ascending. Seeds biseriate or less commonly crowded into one row, 4-20 in each locule, 1 mm. or less in length.

An ecotype largely of the plateau region to the north of the Great Basin, extending from Eastern Washington and Oregon and Northern Nevada eastward through Idaho and Utah into the Rocky Mountains of Montana, Wyoming and Colorado. The type locality is near Wraith Falls, in the Yellowstone National Park.

Sophia ramosa Rydb. (Bull. Torrey Club 31:556. 1904) is a form intermediate between subsp. *Nelsonii* and subsp. *intermedia* occurring occasionally in the mountains of Colorado and Wyoming.

COLORADO. *Chaffee Co.:* Buena Vista, Eggleston 15343 (GH). *Weld Co.:* New Windsor, Osterhout, June 5, 1901 (C, RM). *Grand Co.:* Sulphur Springs, Osterhout 3238 (DS). *Mineral Co.:* Goose Creek, Murdoch 4782 (DS). WYOMING. *Yellowstone Nat'l. Park:* Wraith Falls, Aven & Elias Nelson 5710 (type, NY, isotypes, C, DS, RM, US); Lava Creek, near Wraith Falls, Detling 2277 (Or); Norris Geyser Basin, Mearns 3041 (DS, US). *Carbon Co.:* Ft. Steele, Tweedy 4479 (NY, US).

Lincoln Co.: Afton, Payson & Armstrong 3330 (RM). *Sublette Co.:* Big Piney, E. B. & L. B. Payson 4348 (RM). *Sweetwater Co.:* Green River, Rydberg, June 25, 1895 (NY); Leucite Hills, Merrill & Wilcox 700 (RM, US). *Teton Co.:* Jackson, Detling 2286 (Or). *Uinta Co.:* Evanston, Sanford, June, 1883 (C). *Albany Co.:* Centennial, Nelson 7961 (RM, US). MONTANA. *Gallatin Co.:* Belgrade, Moore, May 31, 1901 (C, US). IDAHO. *Twin Falls Co.:* Twin Falls, Bennitt 45 in part (RM). *Fremont Co.:* Henry Lake, E. B. & L. B. Payson 2041 (RM); St. Anthony, Quayle 56 (DS). *Blaine Co.:* Picabo, Macbride & Payson 2967 (C, DS, RM, US). *Custer Co.:* Dry Creek, Snake Plains, Palmer 343 (US). UTAH. *Salt Lake Co.:* Salt Lake City, Leonard, June 6, 1884 (C, DS, NY). *Cache Co.:* Logan, Maguire 3433 (C, RM). *Uintah Co.:* North of Dinosaur Nat'l. Monument, Graham 7711 (GH, US). NEVADA. *Elko Co.:* Little Lakes Canyon, Kennedy 569 (C, RM); Elko, Wooton, May 18, 1917 (US). *Humboldt Co.:* Winnemucca, Wooton, May 17, 1917 (US). *Lander Co.:* Austin, Hitchcock 735 (US). *Ormsby Co.:* Empire City, M. E. Jones 3784 (type collection of *D. halictorum* var. *osmiarum* f. *brachypoda*, Po, US). OREGON. *Lake Co.:* Summer Lake, Ferris & Duthie 377 (DS). *Harney Co.:* Malheur Lake, Henderson 8438 (Or). *Baker Co.:* Sumpter, Ferris & Duthie 1052 (DS). *Union Co.:* Kamela, Detling 2212 (Or, W). *Umatilla Co.:* Umatilla, Howell, May 1, 1882 (OSC). *Wasco Co.:* The Dalles, Howell, May, 1882 (DS, Or), Howell 47 (C). WASHINGTON. *Klickitat Co.:* Bingen, Suksdorf 2728 (DS, Or, SCW, US), Suksdorf 2463 (DS, GH, Or, US). *Yakima Co.:* Morgan's Ferry, Suksdorf 242 (GH). *Grant Co.:* Coulee City, Piper 3879 (US). *Adams Co.:* Ritzville, Sandberg & Leiberg 161 (C, US).

6j. **Descurainia pinnata** subsp. **filipes** (Gray) comb. nov.

(*Sisymbrium incisum* var. *filipes* Gray, Pl. Fendl. 8. 1849. *Sisymbrium longepedicellatum* Fourn. Recherch. Crucif. 59. 1865. *Sisymbrium incisum* var. *xerophilum* Fourn. Recherch. Crucif. 64. 1865. *Hesperis longepedicellata* O. Ktze. Rev. Gen. Pl. **2**:934. 1891. *Sophia longipedicellata* Howell, Fl. N. Am. **1**:56. 1897. *Sophia filipes* Heller, Bull. Torrey Club **24**:311. 1897. *Sophia gracilis* Rydb. Mem. N. Y. Bot. Gard. **1**:475. 1900. *Sisymbrium brachycarpon* var. *filipes* Macbr. Rhodora **17**:141. 1915. *Descurainia Rydbergii* var. *eglandulosa* O. E. Schulz, Pflanzenreich 4, Fam. **105**:320. 1924. *Descurainia longipedicellata* O. E. Schulz, Pflanzenreich 4, Fam. **105**:324. 1924. *Descurainia longipedicellata* var. *glandulosa* O. E. Schulz, Pflanzenreich 4, Fam. **105**:325. 1924. *Descurainia longipedicellata* f. *gracilis* O. E. Schulz, Pflanzenreich 4, Fam. **105**:325. 1924. *Descurainia brachycarpa* var. *eglandulosa* O. E. Schulz, Pflanzenreich 4, Fam. **105**:325. 1924. *Sophia glandifera* Osterhout, Bull. Torrey Club **53**:35. 1926. *Sisymbrium longipedicellatum* var. *glandulosum* St. John, Proc. Biol. Soc. Wash. **50**:4 1937.)

Plants 10-65 cm. tall, simple or short-branching. Leaves dark green, 1-7 cm. long, pinnate, the leaflets sometimes again deeply cleft; segments of the upper leaves linear or at times broader, the terminal segment typically greatly elongated, those of the lower leaves from obovate or oblanceolate to oblong or less commonly linear, entire or toothed. Leaves, stems and racemes from glabrous to finely puberulant, typically without glands, but the racemes occasionally glandular. Flowers light yellow and conspicuous, calyx 1.5 2.5 mm. long, corolla 2-3.5 mm. long. Fruiting pedicels typically very slender, 10-15 mm. long, spreading 45°-70°. Siliques broadly linear to clavate, 10-15 (or 20) mm. long but commonly shorter than the pedicels, erect or ascending. Seeds biseriate or very often crowded into one row, 6-18 in each locule, about 1 mm. long.

From the Rocky Mountains of Colorado and Wyoming, mostly west of

the Continental Divide, northwestward through the plateau region of Idaho, Oregon and Washington to the eastern slopes of the Cascade Range, thence southward on the east slopes of the Sierra Nevada, and in the Yosemite Valley. Occurring largely with sagebrush and juniper. Absent from most of the Great Basin except extreme Western Nevada and Northeastern Utah. The type was collected by Spalding on the Clearwater River, in what is now Idaho.

This subspecies is itself comprised of several forms, none of which is sufficiently distinct to warrant its being assigned taxonomic standing, in spite of the fact that they sometimes are restricted in a general way to certain geographical areas. The typical form, as it occurs in most of Eastern Washington and Idaho and parts of Oregon, Montana and Wyoming is very distinct with its long filiform pedicels, long siliques which though narrow are usually subclavate, and the elongated terminal lobes of its leaves. Scattered plentifully through this same area, and still more pronounced in the southern tips of its range is a form in which the fruiting pedicels are shorter and invariably thicker, and in which the siliques are likely to be broader, thereby partaking of some of the qualities of subsp. *intermedia*. In Central Oregon the siliques of *filipes* tend to resemble more closely those of subsp. *Nelsonii* in length. Particularly along the sandy banks of the Middle Columbia River and some of its tributaries there occurs another variation marked chiefly by unusually long and slender siliques which are somewhat torulose, and whose seeds are strictly uniseriate. This is Schulz's *D. Rydbergii* var. *glandulosa*. The few other stations at which it has been collected are so scattered and the specimens grade so closely into the typical form of subsp. *filipes* that it seems unwise to consider it a distinct unit, although in the Mid-Columbia area it may well be undergoing a definite development into a local ecotype. Finally, glandular individuals occur sporadically in subsp. *filipes*, frequently growing in the same colonies with the non-glandular type. It is worth noting that the glandular type tends to have broader siliques than the non-glandular, thus apparently linking two characters which belong rather to subsp. *brachycarpa*. Schulz segregated these glandular plants as *D. longipedicellata* var. *glandulosa*, but, as is so often true throughout this species, this character is too unstable to justify giving its possessors distinct taxonomic recognition.

Gray's error in making *filipes* a variety of *Sisymbrium incisum* was a natural one, since the specimen upon which he based his description does have narrow siliques with the seeds in one series, a character by which *incisa* is very commonly distinguished. Examination of more material, however, would have revealed the more typical biseriate arrangement. This point was apparently unnoticed until attention was called to it by Macbride, who in 1915 transferred the form to its logical position with *brachycarpa*.

BRITISH COLUMBIA. Spence's Bridge, Thompson River, Fletcher 459 (Or); Telegraph Creek, Walker 1210 (RM, US). WASHINGTON. *Chelan Co.:* Entiat, Thompson 6006 (OSC, Th, US); Wenatchee, Whited 1062 (OSC, US), Benson 1320 (DS); Swakane Creek, Thompson 8987 (C, Th). *Grant Co.:* Coulee City, Thompson 6134 (DS, OSC, Th, US). *Spokane Co.:* Spokane, Turesson 45 (RM). *Whitman Co.:* Pullman, Elmer 842 (RM, US), Elmer 322 (C, GH); Rock Lake, Sandberg & Leiberg 101 (C, Or, US). *Yakima Co.:* Rattlesnake Mts., Cotton 364 (RM, US).

Klickitat Co.: Bingen, Suksdorf 512 (type collection of *D. Rydbergii* var. *eglandulosa*, SCW); Sandy banks of the Columbia River, Suksdorf, May 19, 1883 (C, US). *Stevens Co.:* Kettle Falls, Spiegelberg 415 (SCW). *Kittitas Co.:* Vantage, Thompson 8205 (Th, US). *Okanogan Co.:* Green Lake, Omak, Fiker 410 (Th). OREGON. *Deschutes Co.:* Redmond, Whited 13 (Or, OSC, US). *Umatilla Co.:* Umatilla, Jackson, May 11, 1915 (OSC, US). *Crook Co.:* Grizzly Butte, Leiberg 301 (GH, Or, US). *Lake Co.:* Fort Rock, Constance 9538 (Or). *Grant Co.:* Dayville, Peck 16031 (W). *Malheur Co.:* Vale Butte, Henderson 8442 (Or). *Harney Co.:* Burns, Henderson 8441 (Or). *Wallowa Co.:* Snake River Canyon, Constance, Rollins & Dillon 1576 (GH, Th); Wallowa Lake, Peck 18581 (W). *Sherman Co.:* Confluence of Deschutes and Columbia Rivers, Detling 2205 (Or). *Wheeler Co.:* Mitchell, Andrews 653 (Or). *Klamath Co.:* Between Davis Ranch and Merrill, Exped. to Fossil Lake, 1901 (C). *Jackson Co.:* Hunt's, Leckenby, April 19, 1898 (US). *County undetermined:* Sandy banks of the Columbia River, Howell, June, 1880 (Or, OSC). IDAHO. *Nez Perce Co:* Clearwater River, Spalding, without date (type, GH), Sandberg, Macdougal & Heller 59 (GH, US); Lewiston, A. A. & E. G. Heller 2969 (C, RM, US), Hitchcock & Samuel 2513 (DS, Or, RM). *Kootenai Co.:* Rathdrum, Leiberg, May, 1891 (Or). *Jerome Co.:* Shoshone Falls, Palmer 111 (C, US). *Owyhee Co.:* Hot Hole, East Fork Bruneau, Nelson & Macbride 1888 (RM, US). *Bannock Co.:* Pocatello, Palmer 28 (US), Davis, May, 1931 (ISB). *Cassia Co.:* Raft River, Davis, March, 1937 (ISB). *Gooding Co.:* Hagerman, Davis 100 (ISB). MONTANA. *Gallatin Co.:* Bozeman, Blankinship, June 12, 1905 (RM), Jones, June 20, 1902 (RM). *Missoula Co.:* Mt. Sentinel, Hitchcock 2327 (Or, RM). *Beaverhead Co.:* Armstead, E. B. & L. B. Payson 1736 (C, RM). WYOMING. *Carbon Co.:* Hanna, E. B. & L. B. Payson 1695 (RM); 27 miles east of Rawlins, Detling 2303 (Or). *Uinta Co.:* Evanston, Nelson 4560 (RM). *Yellowstone Nat'l. Park:* "Yellowstone Park," Hall, June, 1888 (type of *Sophia gracilis*, NY). COLORADO. *Alamosa Co.:* San Luis Lakes, Ramaley 12531 (RM). *Montrose Co.:* Cimarron, Baker 64 (C, GH, US). *Routt Co.:* Hayden, Osterhout 5226 (type of *Sophia glandifera*, RM). UTAH. *Cache Co.:* Intervale Blacksmith Fork Canyon, B. & R. Maguire 3431 (C). *Summit Co.:* Echo, Jones, May 7, 1890 (DS). *Salt Lake Co.:* Salt Lake City, Rydberg 6015 (RM). NEVADA. *Washoe Co.:* Reno, Cowgill, May 14, 1901 (C, DS, RM); Hunter Creek Canyon, Heller 10401 (DS, US). *Ormsby Co.:* Carson City, King Exped., S. Watson 97 (GH). *County undetermined:* Humboldt Plains, A. Gray, 1872 (GH); Humboldt Valley, King Exped., S. Watson 97 (US). CALIFORNIA. *Lassen Co.:* Susanville, D. K. Gillespie 9325 (DS). *Modoc Co.:* Goose Lake Valley, Austin, May, 1894 (C). *Nevada Co.:* Truckee, Sonne, July, 1896 (C). *Siskiyou Co.:* McAdams Creek, Butler 895 (C, DS, RM, US). *Yosemite Nat'l. Park:* Yosemite Valley, Bioletti, May-June, 1900 (RM).

6k. **Descurainia pinnata** subsp. **Paysonii** subsp. nov.

Plantae annuae, 50-75 cm. altae, ramis adscendentibus; foliis pinnatis, pinnis oblanceolatis vel linearibus, terminalibus multo elongatis, foliis inferioribus rarius bipinnatis; floribus flavis, calyce 2 mm., corolla 2.5 mm. longa; pedicellis fructiferis filiformibus, 18-23 mm. longis, 45°-80° patentibus; siliquis 14-18 mm. longis, late linearibus, erecto-adscendentibus; seminibus uniordinatis vel biordinatis, circa 1 mm. longis, 14-17 in utroque loculo; foliis et parte inferiore caulis canescentibus, racemis et pedicellis glaberrimis aut glabriusculis, calycibus pubescentibus.

Tall annual plants, 50-75 cm. in height, with ascending branches. Leaves pinnate with narrowly oblanceolate or linear leaflets, the terminal leaflet commonly greatly elongated, the lower leaves rarely bipinnate. Flowers yellow, calyx 2 mm. long, corolla 2.5 mm. long. Fruiting pedicels filiform, 18-23 mm. long, spreading 45°-80°. Siliques 14-18 mm. long, broadly linear, erect-

ascending. Seeds uniseriate to distinctly biseriate, 14-17 in each locule, about 1 mm. long. Leaves and lower part of stem distinctly canescent, axis of the racemes and pedicels glabrous or with scattered stellate hairs, calyx lightly pubescent.

Type, 21 miles east of Point of Rocks, Sweetwater County, Wyoming, July 14, 1937, L. E. Detling 2301, in the herbarium of the University of Oregon.

This is similar to subsp. *filipes*, but differs from it in its extremely canescent stems and leaves, and in being typically a much taller plant. It occurs in the arid regions from the Red Desert in Western Wyoming to Southeastern Idaho and Northeastern Arizona.

The distinctive characters of this subspecies were apparently first noticed by E. B. Payson, and several specimens in the Rocky Mountain Herbarium were given a herbarium name by him which was never published.

WYOMING. *Sweetwater Co.:* 21 miles east of Point of Rocks, Detling 2301 (type, Or); 20 miles east of Point of Rocks E. B. & L. B. Payson 2550 (C, OSC, RM); Point of Rocks, Red Desert, Nelson 3078 (GH, RM). *County undetermined:* Flockert's Ranch, Merrill & Wilcox 724 (RM, US). IDAHO. *Fremont Co.:* St. Anthony, Quayle 33 (DS, RM). UTAH. *Uintah Co.:* Dry Fork Creek, Graham 8811 (GH, US). *Grand Co.:* Moab, Harrison 5959 (RM). ARIZONA. *Navajo Co.:* Betatakin Ruins, Peebles & Fulton 11911 (US).

7. *Descurainia Virletii* (Fourn.) O. E. Schulz, Pflanzenreich 4, Fam. 105:322. 1924.

(*Sisymbrium Virletii* Fourn. Recherch. Crucif. 62. 1865. *Hesperis Virletii* O. Ktze. Rev. Gen. Pl. 2:935. 1891.)

Annual plants 40-60 cm. tall, simple or branching widely from the base. Leaves obovate in outline, 1-6 cm. long, all bipinnate to again pinnatifid, the ultimate segments small, oblanceolate to obovate, mostly obtuse. Leaves and lower part of stems sparsely to densely stellate-pubescent; pubescence lacking on the axis of the racemes, but this and the stems moderately glandular. Calyx yellow, sometimes purple-tinged, 1-1.5 mm. long, corolla lighter in color, equalling the calyx in length or slightly shorter. Fruiting pedicels 5-7 mm. long, shorter than the siliques, spreading at right angles to the axis of the raceme. Siliques clavate but not so markedly so as in *D. pinnata* and more attenuate at the apex, 6-8 mm. long, slightly less than 1 mm. wide, straight to slightly arcuate. Style very short or obsolete. Seeds biseriate, elliptical, .5 mm. long, 4-20 in each locule.

A species of the high plateau region of Central Mexico from Chihuahua to Puebla (Map 7). Type collected by Virlet d'Aoust near Valle del Maiz in 1851, no. 565; deposited in the herbarium of the Museum National d'Histoire Naturelle, Paris.

CHIHUAHUA. Valley near Chihuahua, Pringle, April 3, 1886 (US). DURANGO. Vicinity of Durango, Palmer 15 (C, GH, US); Tepehuanes, Palmer 16 (C, US). SAN LUIS POTOSI. San Luis Potosi, Schaffner 153 (GH). GUANAJUATO. Jaral, Schumann 290 (US). HIDALGO. Fula, Pringle 13418 (US), Pringle 13417 (US). PUEBLA. Cholula, Deam 82 (GH); Puebla, Bro. Arsene, Sept. 29, 1906 (US); Acatzinco,

Bros. Amable & Arsene 3563 (US). STATE UNDETERMINED. Route de Mexico a San Luis. Virlet d'Aoust 565 (drawing of type made by B. L. Robinson, GH).

8. *Descurainia streptocarpa* (Fourn.) O. E. Schulz, Pflanzenreich 4, Fam. 105:317. 1924.

(*Sisymbrium streptocarpum* Fourn. Recherch. Crucif. 58. 1865. *Hesperis streptocarpa* O. Ktze. Rev. Gen. Pl. **2**:935. 1891.)

Annual plants, 20-100 cm. tall, commonly branching widely from the base. Leaves .5-7 cm. long, typically of quite uniform size throughout the plant, broadly ovate in outline, pinnate, the pinnae deeply incised or pinnatifid, the ultimate segments usually more or less rounded. Stems, leaves and axis of the racemes moderately stellate-puberulent. Plants typically non-glandular but occasionally an individual is moderately glandular on the axis of the raceme. Sepals yellow or green, ovate, 1-1.5 mm. long, petals equalling them or slightly shorter, whitish, spatulate. Fruiting pedicels 5-8 mm. long, spreading at nearly right angles to the axis of the raceme, often even reflexed. Typically some of the pedicels in a raceme are subtended by pinnately incised bracts 3-15 mm. long, but this feature is not constant. Siliques narrowly linear, 8-12 mm. long, less than 1 mm. wide, somewhat arcuate or less commonly straight, wide-spreading. Style short and blunt. Seeds uniseriate or biseriate, 10-15 in each locule, .5 mm. long, elliptical.

In moist locations in the high mountain regions of Central and Southern Mexico and Guatemala (Map 7).

MEXICO. CHIHUAHUA. "Southwestern Chihuahua," Palmer 421 (C). MEXICO. Valley of Mexico, Bourgeau 9 (GH); Swamps, Chapultepec, Pringle 1463 (GH); "State of Mexico," Rose, Painter & Rose 8613 (US). DISTRITO FEDERAL. Mexico City, Pringle 9400 (GH, US); Tlampam, Valley of Mexico, Pringle 6564 (C, GH, US), Rose & Hay 5495 (US). VERA CRUZ. Xalapa, Coulter 683 (GH); Mt. Orizaba, Seaton 156 (GH, US). Liebmann, without date (US). PUEBLA. Vicinity of Puebla, Bros. Arsene & Nicolas 58 (GH, US), Bro. Arsene 10126 (US), Bro. Arsene 10135 (US); Rancho Posadas, Puebla, Bro. Nicolas, Feb. 20, 1909 (US); Chalchicomula, Nelson 255 (US); Acatzinco, Bros. Amable & Arsene 2241 (US). STATE UNDETERMINED: "Mexique," Berlandier 782 (photograph of type, Par, isotype, DS). GUATEMALA, QUEZALTENANGO. Quezaltenango, Kellerman 5569 (US). DEPARTMENT UNDETERMINED: Trachytberg Chi Lahuh K'ih. C. & E. Seler 3167 (GH, US).

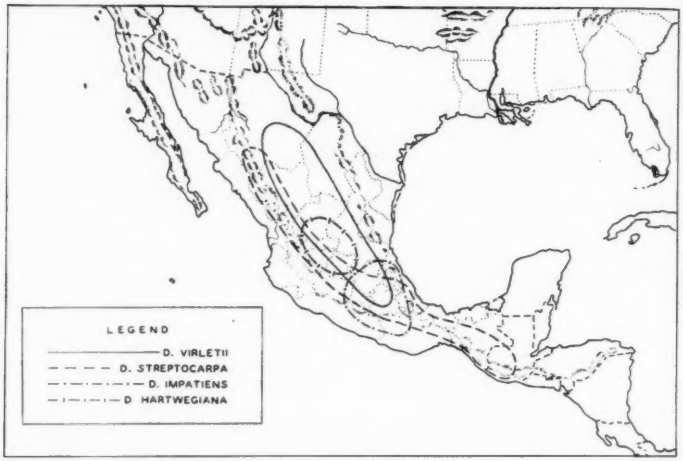
9. *Descurainia impatiens* (Cham. and Schlecht.) O. E. Schulz, Pflanzenreich 4, Fam. 105:318. 1924.

(*Nasturtium impatiens* Cham. & Schlect. Linnaea **5**:212. 1830. *Sisymbrium Galeottianum* Fourn. Recherch. Crucif. 59. 1865. *Sisymbrium Galeottianum* var. *xerophilum* Fourn. Recherch. Crucif. 59. 1865. *Sisymbrium Galeottianum* var. *hygrophilum* Fourn. Recherch. Crucif. 59. 1865. *Hesperis Galeottiana* O. Ktze. Rev. Gen. Pl. **2**:934. 1891. *Descurainia impatiens* var. *xerophila* O. E. Schulz, Pflanzenreich 4, Fam. **105**:318. 1924.)

Annual plants 40-75 cm. tall, branching above and sometimes from the base. Leaves pinnate, the pinnae lanceolate, deeply and sharply toothed or incised. Lower leaves, stems and axis of the racemes moderately stellate-puberulent, upper leaves glabrous or glabrescent. No glands present on the plant. Fruiting pedicels 6-10 mm. long, spreading about 45°, the lower ones typically subtended by simple or trifid bracts. Flowers yellow, calyx 2 mm.

long, the corolla about equalling it. Siliques about 12-15 mm. long, linear, standing nearly erect or occasionally spreading as much as 45°, somewhat torulose. Style short and blunt. Seeds strictly uniseriate, about 1 mm. long, 10-18 in each locule.

A species of the high mountains of Southern Mexico, occurring at times above timber-line (Map 7).



Map 7. Distribution of the Mexican and Central American species of *Descurainia*.

Fournier seems to have conceived of *Sismybrium Galeottianum* as being comprised of two varieties: the first, var. *xerophilum*, a smaller form apparently growing in drier situations or at higher altitudes, and of which Galeotti 4680 is the type; the other, var. *hygrophilum*, a taller form from more moist or lower places, the type of which is Galeotti 4682. The latter specimen is by some considered the type of his species, although Fournier did not so designate it.

MEXICO. Sierra de las Cruces, Pringle 7068 (GH); Cima, Rose & Painter 7163 (US). VERA CRUZ. Mt. Orizaba, Rose & Hay 5724 (US), Seaton 244 (GH, US). PUEBLA. Ixtaccihuatl, Purpus 1652 (C, GH, US); Mt. Popocatepetl, Rose & Hay 6055 (US). OAXACA. In the Cordillera, 8-9000 ft., Galeotti 4682 (photograph of *type of Sisymbrium Galeottianum* var. *hygrophilum*, Par); Sierra de San Felipe, Smith 808 (US); Cerro San Felipe, Nelson 1104 (US). STATE UNDETERMINED: Route de Mexico a San Luis, Virlet d' Aoust 564 (drawing by B. L. Robinson, GH).

10. *Descurainia Hartwegiana* (Fourn.) Britton, Mem. Torrey Club 5:173. 1894, as to synonymy only.

(*Sisymbrium Hartwegianum* Fourn. Recherch. Crucif. 66. 1865. *Sisymbrium incisum* var. *Hartwegianum* S. Wats. in Brew. and Wats. Bot. Calif. **1**:41. 1876, as to synonymy only. *Hesperis Hartwegiana* O. Ktze. Rev. Gen. Pl. **2**:934. 1891.)

Annual plants, 30-45 cm. tall, with short ascending branches above. Leaves small, 15-25 mm. long, ovate, pinnate with the pinnae deeply incised, the ultimate segments short and obtuse. Leaves canescent, stems moderately pubescent; axis of the racemes moderately glandular. Flowers 1-1.5 mm. long. Fruiting pedicels 4-8 mm. long, spreading about 45° from the axis of the raceme. Siliques 5-10 mm. long, mostly longer than the pedicels, standing erect and parallel with the axis of the raceme, subclavate, but the apex of the valves acutish. Seeds uniseriate to biseriate.

A species of the arid plateau of Central Mexico; South America (Map 7). The type collection is Hartweg's 38, from Mexico. The Kew Herbarium sheet of this bears the notation "Zacatecas," while the British Museum specimen is labelled "Guanajuato." The North American distribution of the species is known to me only through this collection. Bourgeau's collection from Saskatchewan, cited by Fournier, is *D. Richardsonii* subsp. *typica*.

MEXICO. "Zacatecas," Hartweg 38 (K); "Guanajuato," Hartweg 38 (photograph, BM).

SUMMARY

1. The treatment of the species is based not only upon morphological differences and similarities, but upon geographical and environmental distribution as well.

2. When a species is widely distributed it naturally occurs under varying environmental conditions. Through the selective action of the environment adaptive characters become genetically fixed in local populations. Such populations, when interfertile, are considered subspecies, and together make up the species.

3. According to this concept, the native North American species of *Descurainia* are 9 in number, composing 17 subspecies. One other species is adventive from the Old World.

4. The center of distribution of the native species is in the southwestern United States, and the least stability of characters is found here. Most of our species presumably originated in this region.

5 The reliability of the characters generally used in the taxonomy of the species is discussed.

PARTIAL INDEX TO THE SYNONYMY

(Only invalid names or those likely to be confusing are included in this list.)

Cardamine multifida Pursh—*D. pinnata* subsp. *typica*
Descurainia halictorum var. *osmiarum* f. *brachypoda* O. E. Schulz—*D. pinnata* subsp. *Nelsonii*
Descurainia longepedicellata var. *glandulosa* O. E. Schulz—*D. pinnata* subsp. *filipes*
Descurainia Menziesii var. *villosa* O. E. Schulz—*D. pinnata* subsp. *typica*
Descurainia multifoliata Cory—*D. pinnata* subsp. *typica*
Descurainia pinnata f. *simplex* O. E. Schulz—probably *D. pinnata* subsp. *brachycarpa*

Descurainia Richardsonii var. *macrosperma* O. E. Schulz—*D. Richardsonii* subsp. *procera*
Descurainia Rydbergii O. E. Schulz, in part—*D. Richardsonii* subsp. *viscosa*
Descurainia Rydbergii var. *eglandulosa* O. E. Schulz—*D. pinnata* subsp. *filipes*
Sisymbrium californicum S. Wats.—*D. californica* as to synonymy and as to the Sierra Nevada plants in part, but—*D. Richardsonii* subsp. *viscosa* as to the Nevada plants
Sisymbrium canescens Nutt.—*D. pinnata* subsp. *typica*
Sisymbrium canescens Richards., not Nutt.—*D. Richardsonii* subsp. *typica*
Sisymbrium canescens var. *californicum* T. & G.—*D. pinnata* subsp. *Menziesii*
Sisymbrium canescens var. *major* Hook.—*D. pinnata* subsp. *typica* as to synonymy, but—*D. Richardsonii* subsp. *typica* as to description and range.
Sisymbrium Cumingianum of authors, not Fisch. & Mey.—*D. obtusa* subsp. *typica* and subsp. *adenophora*.
Sisymbrium Caleottianum Fourn.—*D. impatiens*
Sisymbrium Hartwegianum of authors, not Fourn.—*D. Richardsonii* subps. *procera*
Sisymbrium incisum var. *Hartwegianum* S. Wats.—*D. Hartwegiana* as to synonmy, but—*D. californica* as to the Sierra Nevada plants, and *D. Richardsonii* subsp. *procera* as to the Rocky Mt. plants
Sisymbrium incisum var. *Sonnei* Rob.—*D. Richardsonii* subsp. *incisa*
Sisymbrium incisum var. *xerophilum* Fourn.—*D. pinnata* subsp. *filipes*
Sisymbrium longepedicellatum Fourn.—*D. pinnata* subsp. filipes
Sisymbrium multifidum subsp. *brachycarpum* f. *eglandulosum* Thell.—*D. pinnata* subsp. *filipes*
Sisymbrium parviflorum Lam.—*D. Sophia*
Sisymbrium Sophia Pursh, not L.—*D. pinnata* subsp. *typica*
Sophia andrenarum Ckll.—*D. pinnata* subsp. *halictorum*
Sophia andrenarum var. *osmiarum* Ckll.—*D. pinnata* subsp. *halictorum*
Sophia brevipes Rydb.—*D. Richardsonii* subsp. *procera*
Sophia californica Rydb.—*D. pinnata* subsp. *Menziesii* as to synonymy, but—*D. Richardsonii* subsp. *viscosa* as to description and range.
Sophia glandifera Osterhout—*D. pinnata* subsp. *filipes*
Sophia glandulifera Rydb.—*D. Richardsonii* subsp. *procera* × subsp. *viscosa*
Sophia gracilis Rydb.—*D. pinnata* subsp. *filipes*
Sophia leptophylla Rydb.—*D. Richardsonii* subsp. *incisa*
Sophia leptostylis Rydb.—*D. californica*
Sophia magna Rydb.—*D. pinnata* subsp. *brachycarpa*
Sophia purpurascens Rydb.—*D. Richardsonii* subsp. *incisa*
Sophia ramosa Rydb.—*D. pinnata* subsp. *intermedia* × subsp. *Nelsonii*
Sophia serrata Greene—*D. Richardsonii* subsp. *incisa*
Sophia Sonnei Greene—*D. Richardsonii* subsp. *incisa* as to synonymy, but—*D. californica* as to description.

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Some Realignments in the Genus Nemacladus

Rogers McVaugh

It has recently been the writer's privilege to examine most of the available herbarium material of *Nemacladus*, an endemic campanulaceous genus of western North America. In the light afforded by thorough study of this material, it appears that the number of clearly recognizable species is somewhat greater than previously supposed. Fifteen years ago Dr. Philip A. Munz[1] published a revision of the genus, recognizing three species, with three varieties of one and six varieties of another, making a total of ten named entities. In the present paper there are recognized fourteen entities, grouped under nine species. It may well be that further herbarium study of this difficult genus, supplemented by adequate field studies of its several components, will justify the consideration, as species, of some of these entities here regarded as varieties.

The genus *Nemacladus* offers considerable difficulty to the student because of the superficial resemblance which most of the species bear to each other. Cauline leaves are almost invariably lacking, and the leaves of the basal rosette are not long-persistent. Plant habit is similar in all the species and size-characters prove to be weak and untrustworthy when applied to the plant as a whole or to the vegetative parts in general. The flowers are minute; they rarely exceed five millimeters in length and are usually much smaller than this.

In Munz' revision of the genus in 1924, specific limits were determined almost wholly by the use of the characters of the corolla and those of the staminal appendages peculiar to this genus. With the exception of the very distinct *N. longiflorus*, all entities recognized by Munz were grouped into two species, each with several varieties. Those plants having "Corolla with petals united for $^1/_3$ to $^1/_2$ its length . . . stamineal appendages with very slender transparent cells, which extend straight out from the base so as to appear fan-like" were considered as varieties of *N. ramosissimus* Nuttall, while plants having "Corolla with petals united only at very base . . . stamineal appendages with somewhat clavate, rather thick, transparent cells which are at right angles to basal piece" were placed together as varieties of *N. rigidus* Curran.

In the opinion of the present writer the characters outlined above, while indicating to some extent the various degrees of relationship, are not strong enough in themselves to justify their use as the sole criteria for determining specific limits. Study of herbarium material shows that, as in the other genera of the *Lobelioideae*, valuable characters are furnished by the seeds, the fruits, the stamens, the calyx, the flower-bracts and the pedicels. Using these characters in addition to those elaborated by Munz, it has been possible to set

[1] Munz, Philip A. *A Revision of the Genus Nemacladus (Campanulaceae)*. Amer. Journ. Bot. **11**:233-248. 2 plates. 1924.

forth what seems to be a more logical arrangement of the genus than has heretofore been proposed. The principal distinguishing features of the species, as understood by the writer, are indicated below in the analytical key to the genus. Additional discussion of the reasons underlying the changes of taxonomic status here proposed will be found under the treatment of individual species in the body of the paper.

In citing specimens from different herbaria, the following abbreviations are used: Academy of Natural Sciences of Philadelphia (ANS); California Academy of Sciences (CalAc); Catholic University of America (Cath); Herbarium of E. L. Greene, University of Notre Dame (ELG); Gray Herbarium, Harvard University (G); Missouri Botanical Garden (Mo); Herbarium of The National Arboretum (NatArb); New York Botanical Garden (NB); Pomona College (P); Stanford University (S); University of California (UC); University of Pennsylvania (UP); United States National Herbarium (US); Willamette University (WU). The writer expresses his sincere appreciation to those at the several herbaria who have cooperated so willingly in the present study and who have placed at his disposal the collections in their charge.

NEMACLADUS Nuttall, Trans. Amer. Phil. Soc. n.s. 8:254. 1843

Small annual herbs with 1 to 18 mostly wiry or filiform, often diffusely branched stems from an erect taproot, milky juice (according to Nuttall) and thickish or fleshy leaves mostly or wholly confined to a compact basal rosette. Cauline leaves alternate, entire, largely reduced to subulate or linear bracts at the bases of the branches. Branches mostly weakly or strongly zigzag, the branching fundamentally monopodial, but often apparently dichotomous, the lateral branches frequently equalling or surpassing the main axis and the plant becoming bushy and diffuse thereby. Flowers loosely racemose on all the branches; branches floriferous nearly to the base, so that the inflorescence comprises half to three-quarters or even more of the whole plant. Pedicels wiry or filiform, ebracteolate; bract at base of pedicel linear to ovate, entire, decurrent, not to be distinguished from the bract ("cauline leaf") at base of a branch.

Corolla irregular, more or less distinctly bilabiate, the lower lip two-, the upper three-lobed. Corolla-tube about equalling the lobes or much shorter. Calyx-tube adherent to the lower part of the ovary or nearly free, usually smooth and glabrous. Calyx-lobes triangular to ovate, entire, mostly smooth and glabrous, blunt-pointed. Stamens monadelphous, the filaments separate below and sometimes above as well, the staminal tube surmounted by the stellately spreading distinct anthers. Anthers elliptic-oblong to almost globose, usually obtuse at tip, often mucronate. Staminal tube and the inclosed style abruptly curved near the tip, at least in bud, the style and sometimes the stamens becoming erect in anthesis.

Ovary with three flattened rounded glands near the base of the free part, these opposite the three lobes of the upper lip of the corolla and alternating with the free bases of the filaments. Filaments between these glands (i.e. the

two opposite the two upper calyx-lobes) usually bearing small appendages, each stipe-like and with one or more terminal, transparent rod-like cells.

Capsule fundamentally bilocular, loculicidally dehiscent by two valves; loculus sometimes one only and the valves sometimes splitting longitudinally at tip so that the capsule appears 4-valved.

Seeds varying from nearly globose to ellipsoid or cylindric, with longitudinal ridges or furrows and transverse lines or ridges dividing the surface into pits or transverse striae.

Type species: *Nemacladus ramosissimus* Nuttall, *loc. cit.*

Analytical Key to Species and Varieties

1. Corolla-tube (rarely 2.0) 3.0 to 5.5 mm. long, much exceeding the calyx-lobes; capsule (2.3) 3 to 5 mm. long, free from the calyx its entire length or essentially so ..... 2.
   2. Filament-tube 3.5 to 7.5 mm. long; corolla 5.0 to 8.0 mm. long ..... *N. longiflorus* A. Gray (p. 525)
   2. Filament-tube 2.2 to 2.8 mm. long; corolla 3.0 to 3.5 mm long ..... *N. longiflorus* var. *breviflorus* var. nov. (p. 526)

1. Corolla-tube 1.5 mm. long or less, scarcely or not at all exceeding the calyx-lobes; capsule mostly about half-inferior, the free part not at all or very slightly exceeding the calyx-lobes ..... 3.
   3. Anthers 0.4 to 0.8 mm. long; filaments (1.8) 2.0 to 3.0 mm. long; corolla-lobes united at very base only, the lobes thus much longer than the tube; leaves entire, obscurely toothed, or pinnatifid-lobed ..... 4.
      4. Lower part of stem silvery-gray, shining; well-developed plants with diffuse and spreading branches and somewhat spreading, rather lax pedicels; range centering in the deserts of southern California, north to Kern and Inyo Counties ..... 5.
         5. Leaves usually elliptic, entire or nearly so, mostly 2 to 3 times as long as wide; pedicels much coarser than a human hair; stipe of staminal appendage shorter than the reflexed terminal cells, which are more than 0.5 mm. in length ..... *N. rubescens* Greene (p. 532)
         5. Leaves oblanceolate, pinnatifid-toothed, mostly 5 to 8 times as long as wide; pedicels finely capillary, the diameter about equalling that of a human hair; stipe of staminal appendage much longer than the spreading terminal cells, which are much less than 0.5 mm. in length ..... *N. rubescens* var. *tenuis* var. nov. (p. 536)
      4. Lower part of stem purplish or brownish, lacking a silvery-gray sheen; well-developed plants with more or less stiffly ascending branches and pedicels ..... 6.
         6. Seeds with low narrow longitudinal ridges, separated by rows of about 10 to 12 nearly regular shallow pits; range centering in the Sierra Nevada of central and northern California, south to Kern County ..... *N. rubescens* var. *interior* (Munz) comb. nov. (p. 537)
         6. Seeds with sharply impressed lines, separating broad flattened longitudinal ridges; each ridge with about 15 to 30 fine transverse lines.... 7.
            7. Seeds 0.8 to 0.9 mm. long; Lake and Napa Counties, California ..... *N. montanus* Greene (p. 543)
            7. Seeds 0.6 mm. long or less; southern California, eastward and southward ..... vars. of *N. glanduliferus* Jepson (p. 540)
   3. Anthers 0.1 to 0.3 (rarely 0.4) mm. long; filaments (1.0) 1.3 to 2.0 (2.5) mm. long; corolla-lobes united at base only or the corolla-tube about equalling the lobes; leaves entire, toothed or pinnatifid ..... 8.
      8. Seeds with sharply impressed longitudinal lines separating distinct, somewhat flattened, longitudinal ridges; each ridge with

15 to 30 fine transverse lines; corolla usually more than 1.5 mm. long, divided nearly to base; corolla-lobes much exceeding the very short corolla-tube ..... 9.

9. Plants diffuse, less than 5 cm. tall; known only from Rosario, Baja California .....
.....*N. glanduliferus* var. *australis* (Munz) comb. nov. (p. 540)

9. Plants erect, seldom diffuse, 5 to 25 cm. tall; extreme northern Mexico and southwestern United States ..... 10.

10. Pedicels usuually curved near the tip, the flower and fruit erect; calyx-lobes (1.3) 1.5 to 2.5 (3.0) mm. long .....
.....*N. glanduliferus* Jepson (p. 538)

10. Pedicels stiffly spreading-ascending, not or scarcely curved; calyx-lobes 0.8 to 1.5 (2.3) mm. long .....
.....*N. glanduliferus* var. *orientalis* var. nov. (p. 540)

8. Seeds pitted or the surface with narrow zigzag ridges, the depressions usually in well-defined longitudinal rows, the ridges never separated by sharply impressed longitudinal lines; each row with 6 to 15 depressions or pits; corolla-tube about equalling the lobes, or, if very short, the corolla not more than 1.5 mm. long .....11.

11. Stems perfectly straight, not at all zigzag; bract at base of pedicel (2.0) 3.0 to 5.0 (9.0) mm. long, linear, loosely spreading, not at all enfolding the base of the pedicel; seeds nearly globose, with about 6 pits in each row .....*N. ramosissimus* Nuttall (p. 531)

11. Stems zigzag, often strongly so; seeds distinctly longer than broad .....12.

12. Corolla divided almost to base, 0.7 to 1.5 mm. long, scarcely if at all exceeding the calyx-lobes 13

13. Plant compact, robust, mostly 5 to 10 cm. high; capsule much enlarged in fruit, about half-inferior, 3 to 4 mm. long when mature, sharp-pointed, many-seeded .....*N. rigidus* Curran (p. 545)

13. Plant delicate, with slender stems and filiform pedicels, mostly 10 to 15 cm. high; capsule little enlarged in fruit, 1.5 to 2.7 mm. long, the base long-turbinate, the free part rounded; seeds few, usually 5 to 12 .....*N. capillaris* Greene (p. 547)

12. Corolla tubular below, the tube equalling the lobes or nearly so; corolla (1.0) 1.3 to 2.3 mm. long, usually distinctly exceeding the calyx-lobes .....14.

14. Mature capsule 3.0 to 4.0 mm. long, firm, sharp-pointed; basal leaves usually pinnatifid; pedicels usually abruptly upcurved near tip but not spreading in a graceful double curve; bract at base of pedicel mostly linear, not or scarcely enfolding the base of the pedicel .....
.....*N. pinnatifidus* Greene (p. 529)

14. Mature capsule 1.5 to 2.5 mm. long, obscurely pointed, the free part delicate and often fracturing irregularly at maturity; basal leaves entire or toothed; pedicels spreading in a graceful double curve, the flower somewhat upcurved; bract at base of pedicel lanceolate to ovate, sometimes broader than long, in dried material usually conduplicate, completely enfolding and concealing the base of the pedicel .....
.....*N. gracilis* Eastwood (p. 526)

1. *Nemacladus longiflorus* A. Gray, Proc. Amer. Acad. 12:60. 1876. Type locality: "S.E. California" Type: *Wallace*, without data, in the Gray Herbarium.

Branches spreading-ascending. Plants (3.5) 6.0 to 18.0 (21.0) cm. tall. Stem usually minutely pubescent, at least below (sometimes the whole plant pubescent except the flower), dull or somewhat lustrous, brownish or purplish.

Rosette-leaves few to 30, oblanceolate to obovate or spatulate, usually obtuse at tip and narrowed gradually to a broadly winged base, entire or finely crenate, greenish to purplish when dry. Blades 0.15 to 0.3 (0.4) cm. wide by (0.2) 0.5 to 1.1 cm. long, mostly 1.5 to 3.0 times as long as wide, mostly densely pubescent above and below.

Pedicels wide-spreading to ascending, often strongly bowed upward near base or toward the middle, mostly abruptly bent near tip so that the flower and fruit are erect or nearly so. Fruiting pedicels (6.0) 10.0 to 23.0 mm. long, slender but hardly capillary, distinctly thicker than a Caucasian human hair, smooth and glabrous. Flower-bracts elliptic to lanceolate or ovate, ciliate on margins or on the upper (adaxial) surface, or sometimes on the abaxial surface; occasionally wholly glabrous. Bracts mostly bluntly pointed, 2.0 to 4.0 mm. long, apparently fleshy, in dried material folded about the base of the pedicel and wholly or partially concealing it.

Calyx-tube almost none. Calyx-lobes in anthesis closely appressed to the corolla, nearly parallel, their edges approximate; in fruit the calyx-lobes separated by the expanding capsule, somewhat spreading. Capsule fusiform, varying to ovoid, subacute at each end, 1.5 to 2.0 (2.3) mm. in diameter by (2.3) 3.0 to 4.5 (5.0) mm. long. Calyx-lobes elliptic or lanceolate, subacute, 1.0 to 2.3 mm. long.

Corolla white (often tinged with pink?); upper lip bearded at base on inner surface, with a yellowish spot at base of each of the three lobes (Munz, p. 237). Corolla (3.0) 5.0 to 8.0 mm. long, tubular more than half its length, the tube narrowly cylindrical, (2.0) 2.5 to 5.5 mm. long. Filament-tube (2.3) 3.5 to 7.5 mm. long, somewhat exceeding the corolla-tube, abruptly curved near tip and usually hairy above the curve. Appendages below middle of filament, very small, with few very delicate spreading terminal cells. Anthers 0.3 to 0.5 (0.6) mm. long.

Seeds broadly ellipsoid, small, 0.5 mm. long or less, with obscure undulate or zigzag longitudinal ridges and poorly defined pits; ridges mostly 8 to 10; pits in each row 10 to 12.

Dry sandy or gravelly slopes, in washes or on partially shaded hillsides (chaparral), sometimes in recent burns or clearings. At altitudes of 300 to 1700 meters, from Los Angeles and San Bernardino Counties, California, south to northern Baja California A fragment from the Torrey Herbarium, collected by Charles Wright, now in the New York Botanical Garden, is labelled "near Frontera, Texas." This may be from Fronteras, Sonora.

Collected in flower and fruit mostly from May 1 to July 1.

This is a very distinct species, being characterized by the long narrow corolla-tube and by the essentially superior ovary and fruit. In the original description of the species, Gray states: "A specimen of this, collected by Mr.

Wallace (probably between Los Angeles and San Bernardino), has long been in our herbarium, but the characters have been noticed only now upon the coming of fine specimens collected recently by Mr. Lemmon." The Wallace specimen is chosen by the present writer as the type of the species because of its earlier date of collection and because there is at least an indication as to the collector's locality. In the Gray Herbarium the Wallace collection and that of Lemmon are both without data other than "California" and are about equally well-preserved.

The species most closely related to *N. longiflorus* is apparently *N. gracilis*. The two are almost identical in habit and in size and shape of pedicels and bracts; they resemble each other closely in size and shape of leaves, and the leaves of *N. gracilis* often approach those of *N. longiflorus* in amount and quality of pubescence, as do those of no other species. The seeds of the two are very nearly identical and the staminal appendages show considerable similarity.

A full list of exsiccati may be found in Munz' paper. His concept of *N. longiflorus* was identical with the present one except that it included var. *breviflorus*, which is described separately below.

2. **Nemacladus longiflorus** var. **breviflorus** var. nov.

Type locality: Roadside Mine, between Tucson and Sells, Pima Co., Arizona. Type: *Peebles et al. 3754*, Mar. 27, 1927; in the United States National Herbarium.

A varietate typica corolla breviore, staminibus brevioribus, caule aliquanto breviore discedit. Planta plerumque pubescens, corollis 3.0-3.5 mm. longis, tubo 2.0-2.5 mm. longo; tubo filamentorum 2.2-2.8 mm. longo, non exserto; antheris 0.25-0.3 mm. longis.

Differs from the typical form by the shorter corolla, shorter stamens, the somewhat smaller average size and the more general occurrence of pubescence.

Leaves of the basal rosette and those of the stem, if any, mostly densely pubescent; flower-bracts usually pubescent on both sides, often strongly so; stem pubescent below and often above; pedicels and calyx sometimes pubescent.

Corolla 3.0 to 3.5 mm. long, the tube 2.0 to 2.5 mm. long. Filament-tube 2.2 to 2.8 mm. long, included in the corolla; anthers 0.25 to 0.3 mm. long.

Habitat same as that of the typical form. Mountains along the western borders of the Mohave and Colorado Deserts, California and at an apparently isolated station in south-central Arizona.

Collected in flower and fruit from March 27 to May 17.

Specimens Examined: CALIFORNIA: Mohave Desert, *S.B. & W.F. Parish 1339* (G, S); Covington Ranch, Little San Bernardino Mts., *Munz & Johnston 5165* (P, UC); Morongo Valley, *F. R. Fosberg S2284* (UP); RIVERSIDE: Banning, *M. E. Jones*, May 11, 1903 (P); SAN DIEGO: Vallecito Canyon, Laguna Mts., *Munz 9720* (P); 2 mi. e. of Banner, *Hill et al. 82* (P); Banner, *M. E. Jones*, April 19, 1906 (P); between Jacumba and Mountain Spring, *A. Eastwood 9513* (CalAc).

ARIZONA: PIMA: Roadside Mine, between Tucson and Sells, *Peebles et al. 3754* (P, US).

3. *Nemacladus gracilis* Eastwood, Bull. Torr. Bot. Club 60:500. 1903. Type locality: Alcalde, Fresno Co., Calif. Type: *Alice Eastwood,* May 9, 1893, no. *54591* of the herbarium of the California Academy of Sciences.

Nemacladus ramosissimus var. *gracilis* (Eastwood) Munz, Amer. Journ. Bot. **11**:240. 1924.

Branches weakly or strongly zigzag, often divaricate. Plants 4.0 to 12.0 (19.0) cm. tall. Stem wholly glabrous or pubescent below (the whole plant infrequently pubescent), dull or somewhat lustrous, brownish or purplish.

Rosette-leaves usually fewer than 10, ovate to elliptic, usually obtuse at tip and often narrowed abruptly to a very short petiolar base, entire or minutely dentate, rarely subpinnatifid. Color of dry leaves variable, from green to brownish or purplish, sometimes yellowish. Blades 0.1 to 0.3 (0.45) cm. wide by 0.25 to 0.6 (0.8) cm. long, mostly 1.25 to 2.5 times as long as wide, mostly pubescent at least on the lower (abaxial) surface, often densely so.

Pedicels wide-spreading to ascending, often strongly bowed upward near base or toward the middle, mostly abruptly bent or curved near tip so that the flower and fruit are erect or nearly so, the double curve of the pedicel often a conspicuous feature of the plant. Fruiting pedicels (8) 10 to 16 mm. long, slender but hardly capillary, distinctly thicker than a Caucasian human hair, smooth and glabrous (rarely minutely ciliate on upper side near base). Flower-bracts usually ovate, when flattened out almost as wide as long (sometimes wider than long), glabrous or ciliate on margins or on adaxial surface, blunt at tip, apparently fleshy, 0.7 to 2.0 (3.0) mm. long, sometimes as much as 2.5 mm. wide, usually conduplicate at base and wholly concealing the base of the pedicel.

Calyx rounded at base or acute, the tube cup-shaped in anthesis, little modified in fruit. Capsule half-inferior or slightly less, (1.2) 1.5 to 2.0 (2.5) mm. in diameter, about as wide as high, the free part rounded. Calyx-lobes narrowly triangular to rounded-deltoid or lance-ovate, subacute, 0.6 to 1.5 (2.0?) mm. long.

Corolla white (according to Munz), 1.0 to 3.0 mm. long, campanulate, the tube 0.5 to 1.5 mm. long, 0.3 to 0.6 times as long as the whole corolla. Filament-tube 1.0 to 2.0 mm. long, abruptly curved near tip. Appendages near base of filament; stipe very short and bearing several (6 to 10) very delicate spreading hairlike and pointed cells, which are about 0.25 mm. in length. Anthers 0.2 to 0.35 mm. long.

Seeds broadly ellipsoid, slightly exceeding 0.5 mm. in length, with about 10 obscurely defined undulate or zigzag longitudinal ridges and rows of 10 to 12 irregular shallow pits alternating with the ridges.

Dry sandy or gravelly soil, from open desert sand to newly cleared fields, partial shade in chaparral or washes and on exposed hillsides. Best developed near and in the mountains bordering the deserts of southern California. Southern Washoe County, Nevada and Monterey County, California, south to Baja California, principally west of the Mohave and Colorado Deserts. Reported from Arizona.

Collected in flower and fruit mostly from May 1 to July 1, but some collections as early as April 1 or as late as October 1.

A variable but easily recognized species, seemingly quite distinct from all others with which it has been identified. The type, collected by Miss Alice Eastwood in 1893 at Alcalde, Fresno Co., Calif. (Cal. Acad. Sci. 54591), is scarcely representative of the bulk of material here included in the species. It is rather more slender than the majority of plants from other parts of the range, with shorter and more slender pedicels, flower-bracts which are relatively little clasping and relatively large stamens. Most of the plants collected in the west-central part of the range of the species, from Kern and Fresno Counties west to San Luis Obispo County, agree exactly with the type. In some plants the anthers may reach a length of as much as 0.4 mm.; these may be distinguished at once from *N. rubescens* by the campanulate corolla.

With the possible exception of the above large-flowered race, there appears to be no variant within this species which may be correlated with geographic range. Such characters as length of corolla-tube, length of calyx-tube, thickness of pedicels and size of plant seem to be of slight significance in this respect. The writer has seen no specimen intermediate between *N. gracilis* and *N. ramosissimus* and hence feels that it is impossible to maintain the former as a variety of the latter. The intermediates cited by Munz (p. 242) are, in the opinion of the present writer, clearly *N. gracilis*, with the exception of M. E. Jones' collection at San Felipe Hill in 1906, which is *N. glanduliferus* Jepson. *Abrams 1899*, from Mt. Wilson, appears anomalous, but is certainly not to be placed with *N. ramosissimus*.

Specimens with the campanulate corolla of *N. ramosissimus* and *N. gracilis* may at once be separated from each other by one or several characters:

gracilis	*ramosissimus*
Stems zigzag, at least somewhat so	Stems perfectly straight
Racemes not secund	Racemes usually strongly secund
Pedicels with a symmetrical double curve	Pedicels lax, divaricate, not plainly symmetrically curved
Flower-bracts usually less than 2.0 mm. long, fleshy, mostly clasping the base of the pedicel	Flower-bracts 3 to 6 mm. long, usually flat, lax, not at all clasping
Seeds ellipsoid	Seeds globular or nearly so

Nemacladus gracilis is in all essential respects the plant treated by Munz as *N. ramosissimus* var. *gracilis*. The following list of specimens is, therefore, restricted to those collected since the publication of Munz' revision, those collected but not seen by him prior to that time and those not cited by him under this species.

Specimens Examined: CALIFORNIA: Mohave, (Kern Co.?) *M. E. Jones*, May 11, 1917 (ANS, CalAc, NB, S, UC); Salt Spring, Upper Mohave Desert, *T. Craig 813* (P); "California, Arizona, &c.," *E. Palmer 300* (NB); Mohave Desert, *K. Curran*, in 1884 (P). INYO: Bishop, Owen's Valley, *M. E. Jones*, May 15, 1897 (P); near Little Lake, *Hall & Chandler 7362* (P, UC); between Stewart's Valley & Shoshone, *R. S. Ferris 7366* (NB); White Mts., east of Laws, *Heller*, May 16, 1906 (ANS). KERN: 9 mi. n. of Ricardo, *Munz 12463* (P, UC); Red Rock Canyon, Mohave Desert, *R. Hoffman*, May 7, 1929 (CalAc); 8 mi. n. of Ricardo, *J. T. Howell 4997* (CalAc). LOS ANGELES: 4 mi. e. of Lancaster, *F. W. Peirson 7265* (P). MONO: Benton Station, *M. E. Jones*, June 16, 1927 (P). MONTEREY: Between

Jolon and "The Indians," *Eastwood & Howell 2398* (CalAc). RIVERSIDE: 7 mi. s.e. of Poppet Flats, *Munz & Johnston 8848* (P); Dry Morongo Valley, *Munz 11922* (P). SAN BERNARDINO: 20 mi. n. of Box S Ranch, *Munz 12440* (P, UC); 15 mi. n. of Victorville, *I. M. Johnston 6503* (P); Granite Mts., 16 mi. e. of Victorville, *F. R. Fosberg S2523* (UP); Kramer, *K. Brandegee*, May, 1913 (NB, P); Coyote Holes, Morongo Pass, *Munz 8151* (P); Goffs, *M. E. Jones*, April 20, 1903 (P); n. of and near Victorville, *M. E. Jones*, May 11, 1926 (G, P); Cima, *Munz 13952* (P); 5 mi. w. of Barstow, *M. Minthorn*, April 28, 1914 (US); Barstow, *K. Brandegee*, May 15, 1905 (P); Cactus Flat, San Bernardino Mts., *Munz 10522* (P); Bear Valley, *Munz 10552* (P); Bear Lake, *M. E. Jones*, Oct. 1, 1925 (P); Rabbit Springs, *S. B. Parish 4956* (NB, US); Little Bear Valley, *C. M. Wilder 743* (P); Morongo Valley, *A. Eastwood 18680* (CalAc); Calico, *J. G. Lemmon 3121* (ELG); Calico, *J. G. Lemmon 3131* (G, UC); Victorville to Lucerne Valley, *A. Eastwood 18738* (CalAc); Sheep Hole Mts. *H. M. Hall 6046* (UC); Kane Spring, Ord Mts., *Hall & Chandler 6819* (UC). SAN DIEGO: Colorado Desert, *C. R. Orcutt*, April 15-25, 1889 (US); San Felipe Wash, 2 mi. e. of Banner, *Keck & McCully 83* (P); 6 mi. e. of Jacumba, *Munz 8078a* (P). SAN LUIS OBISPO: Santa Margarita, *A. Eastwood*, June 10, 1902 (CalAc); Santa Margarita, Eldorado School, *M. E. Wall*, May 25, 1933 (CalAc).

NEVADA: Clark; Good Springs, *M. E. Jones*, April 30, 1905 (P); Las Vegas, *L. N. Goodding 2319* (G, NB, UC).

BAJA CALIFORNIA: La Grulla, *C. R. Orcutt*, May 18, 1886 (NB, UC).

4. *Nemacladus pinnatifidus* Greene, Bull. Calif. Acad. 1:197. 1885. Type locality; All Saints Bay, Baja California. Type: *E. L. Greene*, May 16, 1885, no. *54596* of the herbarium of the California Academy of Sciences.

Nemacladus ramosissimus var. *pinnatifidus* (Greene) A. Gray, Synop. Fl. II, 1:(Suppl.)393. 1886.

Branches usually strongly ascending and more or less stiffly erect, often intricately tangled, at least in dried material. Plants 6 to 15 (20) cm. tall, almost wholly glabrous, the stems purplish or brownish.

Rosette leaves few to 30, oblanceolate, rounded to acute at tip and narrowed gradually to a long petiolar base; blades mostly deeply pinnatifid with toothed lobes (some plants with merely toothed or nearly entire blades). Color of leaves green to purplish or brownish (when dry). Blades 0.15 to 0.4 cm. wide by 0.5 to 2.0 cm. long, mostly 3 to 6 times as long as wide. Pubescence usually wanting. Cauline leaves sometimes well developed, up to 1.0 cm. long, toothed or subpinnatifid.

Pedicels ascending, leaving the stem at an angle of 60° to 90°, somewhat flexuous, straight at base or somewhat bowed upward, mostly bent above the middle so that the flower and fruit are erect. Fruiting pedicels 7 to 13 mm. long, slender but not capillary, distinctly thicker than a Caucasian human hair, smooth. Flower bracts linear to elliptic, smooth and glabrous, blunt at tip, 2 to 5 mm. long, usually somewhat conduplicate at base or occasionally their whole length, but not or scarcely concealing the base of the pedicel.

Calyx in anthesis short-campanulate, rounded or subacute at base; fruiting calyx ellipsoid or campanulate. Capsule 1.7 to 2.2 mm. in diameter by (2.0) 3.0 to 4.0 mm. long, about half inferior, the free part acutely pointed. Calyx-lobes linear to narrowly triangular or elliptic, subacute, 1.2 to 1.8 (2.3) mm. long.

Corolla white (?), 1.6 to 2.0 mm. long, campanulate, the tube 0.5 to 1.0

mm. long. Filament-tube 1.3 to 2.0 mm. long, glabrous, curved near tip. Appendages with thickened base and few to 5 spreading linear cells about 0.25 mm. in length. Anthers 0.1 to 0.2 mm. long.

Seeds ellipsoid, more than 0.5 mm. long, with 8 to 10 longitudinal rows of 8 to 10 broad rounded pits each; rows of pits separated by narrow ridges.

Dry or sterile soil, in washes or in partial shade (chapparal). Coastal slopes of southern California, north to Los Angeles County and south to northern Baja California.

Collected in flower and fruit mostly from May 15 to July 1. Old fruiting specimens have been collected as late as August 30, and fruiting plants have been found as early as April 9.

This somewhat local species is easily recognized, even in the absence of mature fruit, by the elongated pointed capsule and the usually pinnatifid basal leaves. The type material, collected by E. L. Greene at All Saints' Bay, Baja California, May 16, 1885 (Cal. Acad. Sci. 54596), consists of two plants. One is a flowering specimen with well-preserved basal leaves and a few mature capsules; the other is a fruiting specimen with mature capsules and seeds.

Nemacladus ramosissimus var. *pinnatifidus* of Munz' revision was a mixture of *N. pinnatifidus* Greene and what was subsequently described (1925) as *N. glanduliferus* Jepson. To quote Munz: "The most distinctive features (of *N. ramosissimus* var. *pinnatifidus*) are evidently the pinnatifid basal leaves and the long sepals." Examination of herbarium material identified as this variety reveals two unrelated species which have been combined merely because of the usually pinnatifid basal leaves common to both plants. The two differ as follows:

Series 1	*Series 2*
Capsule 3 to 4 mm. long, acute at tip, 1.5 to 2 times as long as wide	Capsule mostly 2.2 to 3.0 mm. long, short-acute, 1 to 1.5 times as long as wide
Calyx-lobes 1.2 to 1.8 (2.3) mm. long	Calyx-lobes (1.3) 1.5 to 2.5 (4.5) mm. long
Seeds pitted, lacking sharply impressed longitudinal lines	Seeds divided longitudinally by sharply impressed lines.

Series 1 represents true *N. pinnatifidus* Greene. Series 2 is identical with *N. glanduliferus* Jepson. The "long sepals" of Munz' var. *pinnatifidus* seemingly belong to *N. glanduliferus* only, while pinnatifid basal leaves may occur in either. The two plants in question are easily and certainly distinguished by the totally dissimilar seeds, but *N. pinnatifidus* may usually be separated from *N. glanduliferus* by the much longer and more acute capsule as well.

As in the case of *N. gracilis*, the writer has seen no intermediates between the present species and *N. ramosissimus*, and can thus see no justification for maintaining it as a variety of that plant. The Hall specimens from Palomar, cited by Munz as intermediates (*Hall 1961b*, in herb. U. of Cal.), have exactly the capsules, seeds, pedicels, bracts and leaves of *pinnatifidus*. The plants collected by M. E. Jones at San Felipe in 1906, are *N. glanduliferus*.

N. pinnatifidus may at once be distinguished from *N. ramosissimus* by its zigzag stem, its ellipsoidal seeds, its elongated and conspicuously pointed

capsule and its stiffer and usually abruptly upcurved pedicels. The pedicel of *N. pinnatifidus* may suggest that of *N. gracilis* but if so the two are easily separated by the size and shape of the capsules, as well as by the shape and pubescence of the basal leaves.

Specimens Examined: BAJA CALIFORNIA: All Saints Bay, *E. L. Greene*, May 16, 1885 (CalAc, G, UC).

CALIFORNIA: Banks of San Gabriel R., *J. B. Leiberg 3385* (US); Casey Trail to San Sevaine Flats, San Antonio Mts., *Johnston 5626* (G, P, S); without loc., *J. B. Leiberg 3385* (S). LOS ANGELES; Echo Mt., *A. J. McClatchie*, without date (NB); Echo Mt., *A. J. McClatchie 733* (S); Santa Anita Canyon, Sierra Madre Mts., *O. D. Allen*, May 23, 1885 (G). RIVERSIDE; 2 mi. w. of Dripping Springs, *Munz 9839* (P); Glen Ivy Trail to Santiago Peak, Santa Ana Mts., *Munz 7096* (P). SAN BERNARDINO; Arrowhead Springs, *J. B. Feudge 34* (P); Devore, *M. E. Jones* (Cath); Devore Station, *Munz 11314* (P); San Bernardino Mts., *S. B. & W. F. Parish 939* (CalAc 54597; specimens bearing this number *(Parish 939)* in the Gray Herbarium, U. S. National Herbarium and Herbarium of Stanford University are without additional data but are doubtless from this locality). SAN DIEGO; Oak Grove, *Munz & Hitchcock 11321* (G, P); Oak Grove trail to Palomar Mt., *Munz 10391* (P, UC); Cootca, Palomar, *H. M. Hall 1961b* (UC); Buckman's Springs, *F. R. Fosberg 8422* (P, UC); 4 mi. s.e. of Buckman's Springs, *Munz 9655* (P,S); Descanso, *K. Brandegee*, June 16, 1906 (P); between Potrero and Cottonwood Valley, *L. R. Abrams 3746* (NB, S).

5. *Nemacladus ramosissimus* Nuttall, Trans. Amer. Phil. Soc. n.s. 8:254. 1843. Type locality: near San Diego, California. Type: "St. Diego, N. Cal." *Nuttall;* in the herbarium of the Academy of Natural Sciences, Philadelphia.

N. tenuissimus Greene, Bull. Calif. Acad. 1:198. 1885. Cotypes from All Saints Bay, Baja California, *E. L. Greene*, May 15, 1885, no. 54603 of the herbarium of the California Academy of Sciences, and from Jamul, San Diego Co., Calif., *C. R. Orcutt* in 1884, no. 54602 of the herbarium of the California Academy of Sciences.

Stems several times forked, the ultimate branches straight and slender, not at all zigzag, often strongly ascending, their length above the last fork often comprising ¾ the height of the plant. Plants 5 to 20 (32) cm. tall. Stem pubescent, at least below, or wholly glabrous, dull or obscurely lustrous, brownish or purplish below.

Rosette leaves few to 20, oblanceolate, obtuse at tip, narrowed gradually to a slender or sometimes broadly winged petiolar base, irregularly toothed to subpinnatifid, greenish, brownish or purplish when dry. Blades 0.1 to 0.14 cm. wide by (0.3) 0.5 to 1.8 cm. long, mostly 5.5 to 6.0 times as long as wide. Pubescence sparse near base on margins and upper surface, or lacking.

Pedicels lax, spreading at base at an angle of about 90° from the stem (often slightly ascending or drooping), often somewhat curved at the middle or above, so that the flower is erect or nearly so. Racemes often strongly secund. Fruiting pedicels (6) 8 to 16 (22) mm. long, finely capillary, as thick as a Caucasian human hair or more slender, smooth and glabrous. Flower-bracts linear, glabrous, blunt-pointed or rounded at tip, (2) 3 to 6 (9) mm. long, usually loosely spreading or even reflexed, mostly quite or nearly flat and not at all concealing the base of the pedicel.

Calyx in anthesis campanulate, becoming broadly conic in fruit. Capsule

half-inferior or less, the free part rounded or obscurely pointed, (1.2) 1.5 to 2.0 mm. in diameter by 1.6 to 2.5 mm. long. Calyx-lobes linear to elliptic or lanceolate, blunt at tip, 0.6 to 1.2 mm. long.

Corolla white (?), glabrous, 1.3 to 2.0 (27) mm. long, campanulate, the tube slightly less than half this length. Filament-tube (1.0) 1.3 to 2.0 mm. long, smooth and glabrous, mostly recurved near tip, and often hidden by the corolla. Appendages consisting of a small cluster of almost sessile clear cells projecting in all directions, these hardly 0.25 mm. in length. Anthers 0.2 to 0.3 mm. long.

Seeds about 0.5 mm. long, almost globular, with 10 rows of about 6 rounded pits.

Dry sandy or gravelly soil, often in semi-shade (chaparral); often in recent burns or clearings. Southern California, mostly near the coast, from Monterey and Inyo Counties south to northern Baja California, west of the Mohave and Colorado Deserts. Ascends to an altitude of at least 1500 meters.

Collected in flower and fruit mostly from April 15 to June 1, but occasionally as late as September 7.

The species as here understood is exactly that of Munz' revision so that no specimens are cited with the exception of a collection made by *M. E. Jones* at "Darwin, Argus Mts., Inyo Co., California." This plant, in the herbarium of Pomona College, is typical *N. ramosissimus* and, if actually from the locality stated, constitutes a considerable extension of the previously known range.

6. *Nemacladus rubescens* Greene, Bull. Calif. Acad. 1:197. 1885. Type locality: Mohave Desert, California. Type: *M. K. Curran*, in 1884, no. *54600* of the herbarium of the California Academy of Sciences, plant no. 1.

N. adenophorus Parish, Bull. S. Calif. Acad. **2**:28. 1903. Type: Rabbit Springs, Mohave Desert, *Parish 4956*, June 1, 1901, no. 102231 of the herbarium of the University of California.

N. rigidus var. *rubescens* (Greene) Munz, Amer. Journ. Bot. **11**:245. 1924, in part.

Branches repeatedly forked and spreading-flexuous, so that nearly all well-developed plants are diffuse and bushy. Plants 5 to 15 (25) cm. tall. Stem slightly pubescent below, sometimes at very base only, or wholly glabrous, the lower part and often the branches as well with a conspicuous silvery-gray sheen.

Rosette leaves few to 30, oblanceolate to elliptic, most often obtuse at tip and narrowed gradually to a broadly winged base, entire or obscurely toothed; color when dry light yellowish-green or yellow, only very rarely purplish. Blades 0.3 to 0.7 cm. wide by 0.7 to 1.8 (2.7) cm. long, 2 to 3 (5) times as long as wide. Pubescence of leaves sparse, on lower part of margin, or lacking.

Pedicels somewhat ascending, leaving the stem at an angle of 90° or less, perfectly straight or slightly bowed upward at base, straight or flexuous at tip, the flower and capsule often turned upward. Fruiting pedicels (6.0) 8.0 to 15.0 mm. long, slender but not finely capillary, distinctly thicker than a coarse Caucasian human hair, smooth and glabrous. Flower-bracts lanceolate to ovate.

glabrous, blunt at tip, 1.0 to 2.0 (3.0) mm. long, strongly decurrent at base; in dried material usually conduplicate so as partially to inclose the pedicel but mostly leaving the base of the pedicel visible on the upper side.

Calyx broadly rounded at base in anthesis, becoming cup-shaped or hemispheric in fruit. Capsule about half inferior, obscurely pointed, 1.5 to 2.0 mm. in diameter, about as broad as high. Calyx-lobes elliptic to deltoid-ovate, subacute, 0.7 to 1.2 (1.4) mm. long.

Corolla yellow, with purplish-brown markings toward the tips of the lobes; margins of the lobes, at least the upper three, ciliate. Corolla (1.5) 2.0 to 3.0 (3.5) mm. long, the tube very short (0.5 mm. or less) and spreading and much exceeded by the spreading lobes. Filament-tube 2.0 to 3.0 mm. long, straight or very slightly curved above, smooth and glabrous throughout, about equalling the corolla but appearing conspicuously exserted because of the spreading corolla-lobes and the short corolla-tube. Appendages consisting of a stipe bearing 3 to 5 reflexed clavate cells 0.6 to 0.7 mm. in length and much exceeding the stipe. Anthers 0.5 to 0.7 mm. long, often purplish.

Seeds 0.5 to 0.75 mm. long, broadly ellipsoid, each with 8 to 10 undulate or zigzag longitudinal ridges and poorly defined pits between the ridges.

Dry sandy, gravelly or rocky soil in deserts, Kern County, California, east to southern Nevada and the desert areas of western Arizona, south to eastern San Diego County, California, and northern Baja California. A plant of the Mohave and Colorado Deserts, most abundant at low altitudes but ascending at least to 1200 meters.

Collected in flower and fruit mostly from April 1 to May 15, but occasionally as late as July.

Nemacladus rubescens was described by Greene in 1885, the description having been drawn up from plants collected the previous year by M. K. Curran at Reno, Nevada, and on the Mohave Desert, California. Examination of the collections in question (Cal. Acad. Sci. 54600 and 54601) shows that three species are represented. The Reno collection consists of a single plant of *N. gracilis* Eastwood. The collection from the Mohave Desert consists of five plants, of which two are *N. gracilis*. The three remaining specimens are apparently those from which Greene drew the following part of his original description: "Corolla apparently open-campanulate, without tube, from light rose-color to dark rose-red; stamineal tube elongated, equalling the calyx in length." In addition to the above specimens there is mounted on the same sheet a packet containing a mixture of fragments of *N. gracilis* and of a third species having the "seed oblong, with undulating striae" as noted in Greene's description.

In his revision of *Nemacladus*, Munz assigned *N. rubescens* to varietal rank under *N. rigidus*. Included by him in this variety were two of the elements making up the original *N. rubescens* of Greene. The third element had been recognized as a species, *N. gracilis*, by Miss Eastwood in 1903.

It becomes necessary, therefore, to designate one of the specimens of Greene's original material as the type of *Nemacladus rubescens*. The diag-

nostic part of the original description was drawn from two specimens in almost equal parts, the description of the flower having been taken from one and the description of the seeds from another. Nothing in the original description can be taken to apply directly and solely to the plant which was later named *N. gracilis* Eastwood. Of the two species remaining, the one with the "beautifully undulate-striate seeds" of Greene's description is certainly a geographical race of *N. glanduliferus* Jepson. It has been included by Munz and most subsequent authors and collectors in *N. rigidus* var. *rubescens*.

There remains the third plant involved in Greene's original diagnosis. This is the plant with large flowers and long staminal tube which was sufficiently characterized in the original description. It is also the plant to which the specific name, *rubescens*, seems to refer. It appears, then, that the name *rubescens* may logically be restricted to this plant with large flowers and long staminal tube, rather than applied to the species of which Greene saw seeds only. It has not previously been recognized as distinct from the variety of *N. glanduliferus* mentioned above, both having been named *N. rubescens* on most herbarium sheets. The type of *Nemacladus rubescens* is thus hereby designated as follows: Specimen no. 54600 of the herbarium of the California Academy of Sciences, collected in 1884 on the Mohave Desert, California, by M. K. Curran (Plant No. 1 only).

In Munz' revision of *Nemacladus*, there were included in *N. rigidus* var. *rubescens* at least three well-marked series, as follows:

Series 1	*Series 2*	*Series 3*
Stem dull or slightly lustrous, brownish or purplish	Stem distinctly lustrous with a conspicuous silvery-gray sheen	As in Series 2
Leaves often purplish, entire or toothed, 1 to 3 mm. wide, 3 to 6 times as long as wide	Leaves yellowish-green, entire or nearly so, 3 to 7 mm. wide, 2 to 3 times as long as wide	Leaves yellowish-green, pinnatifid-toothed, 2 to 4 mm. wide, 4 to 8 times as long as wide
Pedicels not capillary, mostly stiff and straight	Pedicels not capillary, mostly curved upward near tip	Pedicels truly capillary, strongly upcurved near tip
Corolla usually 1.5 to 2.2 mm. long	Corolla usually 2.0 to 3.0 mm. long	As in series 2
Filaments mostly 1.2 to 1.7 mm. long	Filaments mostly 2.0 to 3.0 mm. long	As in series 2
Anthers mostly 0.2 to 0.3 mm. long	Anthers 0.5 to 0.7 mm. long	Anthers 0.4 to 0.5 mm. long
Seeds with 6 to 8 longitudinal ridges separated by sharply impressed lines	Seeds with 8 to 10 longitudinal undulate or zigzag ridges and rows of 8 to 12 obscure pits	As in series 2

As here understood, series 1 represents the geographical variety of *N. glanduliferus* Jepson mentioned above, and will be discussed later. Series 2 and 3 seem to represent geographical varieties of a single species; the former is true *N. rubescens* Greene as here restricted, and the latter is described below as a new variety of this species.

Although all of the above were merged by Munz in *Nemacladus rigidus* Curran var. *rubescens* (Greene) Munz, there seems to be no reason to assign any one of the three to a position close to *N. rigidus* or to the plant described by Munz as *N. rigidus* var. *capillaris*. Series 1 above is clearly distinct from the *rigidus* type by virtue of its very characteristic seeds, which appear to be better indicators of relationship than the somewhat variable corolla, the characters of which have previously been used to align the *rigidus* group with the *glanduliferus* group. Series 2 and 3 differ from *N. rigidus* through the very much larger flowers and, in particular, through the larger stamens. As in the sub-family *Lobelioideae* in general, the most constant and reliable characters in *Nemacladus* appear to be furnished by the markings of the seeds and by the size of the filaments and anthers, with characters of secondary importance in length and quality of pedicels and size and shape of calyx-lobes. Ranking with these in importance as indicators of relationships are size and quality of flower-bracts and of leaves. While size and markings of corolla, as well as the size and shape of its lobes and length of the corolla-tube, are of considerable genetic importance, the amount of variation within a single species is apt to be greater in the corolla than in the associated flower-parts.

Specimens Examined: CALIFORNIA: Mohave Desert, *K. Curran*, in 1884 (P, UC, G); Mohave Desert, *S. B. & W. F. Parish 1338A* (G); Lone Willow Spring, *S. B. Parish 10184* (S); Palm Springs, *Mrs. Wilder*, April, 1907 (S); "California, Arizona, &c" *E. Palmer 300* (G); Greenwater Flat, Mohave Des., *S. B. Parish 9879* (S); Mohave River, S. Cal., *J. G. Lemmon & wife*, May 11, 1884 (UC). INYO: Little Lake, *A. Davidson 2422* (UC, S, US); sand wash near Salt Well, *Hall & Chandler 6886* (UC); Panamint Valley, *S. B. Parish 10164* (S). KERN: Red Rock Canyon, *Eastwood & Howell 3989* (CalAc, Cath, NB); Red Rock Canyon, *R. Hoffman*, May 7, 1929 (CalAc); Red Rock Canyon, *L. R. Abrams 11847* (S). RIVERSIDE: Two Bunch Palms, (Co.?) Colorado Desert, *E. C. Jaeger 441* (US); Dos Palmos Spring, Colorado Desert, *Munz 9979* (P, UC, US); Palm Springs, Colorado Desert, *M. F. Spencer 1498* (G, P); Whitewater, *M. E. Jones*, May 11, 1903 (P, US); near Salton, *H. M. Hall 5838* (UC); Indio, *M. E. Jones*, April 27, 1906 (P). SAN BERNARDINO: Adelanto, *M. E. Jones*, May 12, 1927 (P); Stoddard's Well, *M. E. Jones*, May 7, 1927 (P); Granite Mts., 16 mi. e. of Victorville, *F. R. Fosberg S2554* (UP); 15 mi. n. of Victorville, *I. M. Johnston 6503* (P); ditto, *F. W. Peirson 1209* (CalAc); Victorville to Lucern Valley, *A. Eastwood 18738* (CalAc); "Nipton, Nevada," *M. E. Jones*, May 2, 1907 (P); Kramer, *K. Brandegee*, May, 1913 (CalAc, G, NB, P, UC); Kelso, *M. E. Jones*, May 2, 1906 (G, P, S, US); 20 mi. n. of Box S Ranch, *Munz 12417* (P, UC); Barstow, *K. Brandegee*, May 15, 1905 (US); Barstow, *S. B. Parish 9248* (S); 11 mi. s. of Barstow, *C. L. Hitchcock 12254* (P, UC); north of Barstow, *Clokey and Anderson 6928* (Cath, NB, P); 5 mi. w. of Barstow, *M. Minthorn*, April 28, 1914 (US); San Bernardino, *Lemmon herb.*, May, 1878 (ELG, P, UC); San Bernardino, *S. B. & W. F. Parish 831* (ANS, NB, UC, US); mesas near Rabbit Spring, Mohave Desert, *S. B. Parish 4956* (CalAc, NB, P, S, UC, US); near Calico, *J. G. Lemmon 3132*, May 12, 1884 (ELG); Palm Springs, *A. Eastwood 2991* (CalAc); Victor(ville?), *M. E. Jones*, May 17, 1903 (CalAc, G, P, S); Cronese Valley, Mohave Desert, *Munz 11050* (P); Cronese Valley, *T. Craig 949* (P); Warren's Well, *T. S. Brandegee*, May 16, 1902 (UC); Cima, *K. Brandegee*, June, 1915 (UC); Daggett, *H. M. Hall 6144* (S, UC, US); Daggett, *F. R. Fosberg S433* (UP). SAN DIEGO: Palm Canyon, Borego Valley, *Munz & Hitchcock 11333* (G, P); Hell Hole Canyon near Borego, *Epling & Robinson*, April 5-7, 1932 (CalAc, NB, S); Yaqui Wells, Colorado Desert, *A. Eastwood 2686* (CalAc); s.w. part of Colorado Desert, *C. R. Orcutt*, April 15-25, 1889 (G, US).

NEVADA: Mica Springs, *M. E. Jones 5045n*, April 13, 1894 (P); "Nipton" (see

under San Bernardino Co., Cal.). LINCOLN; Muddy Valley, *Brandegee*, May 7, 1906 (UC). NYE; Rose's Well (Co.?), *M. E. Jones*, April 26, 1907 (P).

ARIZONA: MOHAVE; Beaverdam, *M. E. Jones 5024ad* (US); 8 mi. above Pierce's Ferry, *M. E. Jones 5077a* (US); Yucca, *M. E. Jones 3920* (ANS, CalAc, NB, P, S, UC); Franconia, *M. E. Jones*, April 23, 1903 (P); April 17, 1903 (US). YUMA; 15 mi. s. of Parker, *Wiegand & Upton 4353* (NB).

BAJA CALIFORNIA: La Grulla, *C. R. Orcutt*, May 18, 1886 (NB, UC).

7. **Nemacladus rubescens** var. **tenuis** var. nov.

Type locality: eastern base of Indio Mt., Colorado Desert, Riverside Co., California. Type: *H. M. Hall 5819*, Apr. 17, 1905, no. 614929 of the United States National Herbarium.

Planta varietati typicae similis, a qua foliis rosulatis oblanceolatis, pinnatifidis, laminis 0.15-0.4 cm. latis, (0.7) 1.0-2.3 cm. longis, pedicellis capillaribus, tenuissimis, antheris 0.4-0.5 mm. longis, appendicibus staminium elongatis differt.

Branches several-times forked, spreading-flexuous and usually very diffuse, weakly zigzag below, the ultimate branchlets often practically straight. Plants 9 to 20 cm. tall.

Rosette-leaves oblanceolate, subacute or blunt-pointed at tip, deeply pinnatifid with entire or toothed lobes, gradually narrowed to a long drawn-out petiolar base, yellowish to green when dry, rarely purplish. Blades 0.15 to 0.4 cm. wide by (0.7) 1.0 to 2.3 cm. long, mostly 4 to 8 times as long as wide, sparsely pubescent on both surfaces, especially near base.

Pedicels wide spreading, leaving the stem at an angle of 90° or somewhat less, mostly somewhat bowed upward near the middle and abruptly curved near tip so that the flower and fruit are erect or even slightly incurved. Fruiting pedicels 10 to 17 mm. long, capillary, the thickness about equalling that of a coarse Caucasian human hair, smooth and glabrous. Bracts similar to those of *N. rubescens* but somewhat more strongly folded, often concealing the base of the pedicel.

Capsule 1.3 to 1.6 mm. in diameter by 1.5 to 2.0 mm. long. Calyx-lobes mostly narrowly triangular, acute, (1.0) 1.2 to 1.7 (2.2) mm. long.

Flower essentially as in *N. rubescens*, except for the anthers, which have an average length of 0.4 to 0.5 mm., and the staminal appendage which consists of a stipe 0.5 to 1.0 mm. in length, with 6 to 12 spreading terminal clavate cells less than 0.25 mm. in length.

Dry sandy soil, deserts, southern California. A plant reaching its best development in the Colorado Desert, mostly at altitudes of 300 meters or less, ranging from Imperial and eastern San Diego Counties north to Inyo County.

Collected in flower and fruit mostly from April 1 to April 15. Some collections as early as January 31 or as late as April 27.

Specimens Examined: CALIFORNIA: Borregos Springs, *T. S. Brandegee*, April 17, 1895 (P, UC); Colorado Desert, *T. S. Brandegee*, April 1904 (US). IMPERIAL; 3 mi. e. Coyote Wells, *R. S. Ferris 7110* (S); 2 mi. n. of Cargo Muchacho Mts.,

Munz & Hitchcock 12145 (P); 25 mi. n.e. of Ogilby, *Munz & Hitchcock 12178* (S, UC). INYO; Bradbury's Well, *C. L. Hitchcock 12355* (P, S, UC); 4 mi. s. of Bradbury's Well, *Munz & Hitchcock 10979* (P); Panamint Valley, *S. B. Parish 10111* (S); ditto, *S. B. Parish 10146* (S); Bradbury's Well, *Munz 14894* (P); 12 mi. s.w. of Shoshone, *C. L. Hitchcock 12308* (P); Rhodes Wash, *F. R. Fosberg 5420* (UP). RIVERSIDE; south base of Eagle Mts., Colorado Desert, *Munz & Keck 4824* (P); Shaver's Well, *M. E. Jones*, Feb. 16, 1926 (P); Shaver's Well, near Mecca, *Munz & Keck 4745* (P); Dos Palmos Spring, *Munz 9979* (P, UC); Indio, *M.E. Jones*, April 27, 1906 (P), *M. E. Jones*, April 30, 1906 (S); near Indio, *M.E. Jones*, Feb. 15, 1926 (S); Palm Springs, *L. R. Abrams 11008* (S); e. base of Indio Mt., Colorado Desert, *H. M. Hall 5819* (ANS, G, NB, P, S, UC, US); Box Canyon near Shaver's Well, Colorado Desert, *E. C. Jaeger 217* (US); Two-Bunch Palms (Co.?), Colorado Desert, *E. C. Jaeger 441* (US); Painted Canyon, Colorado Desert, *J. T. Howell 3544* (CalAc); near Salton, *H. M. Hall 5838* (UC); near Salton, *Hall & L. A. Creata 5838* (S). SAN BERNARDINO; Soda Lake, *S. B. Parish 10010* (S); 10 mi. n.w. of Riggs, Mohave Desert, *Munz & Hitchcock 10948* (G, P); The Pipes, near Morongo Valley, *M. E. Jones*, April 12, 1927 (P); Palm Canyon, Palm Springs, *A. Eastwood 2991* (CalAc); Sheep Hole Mts., *H. M. Hall 6046* (UC). SAN DIEGO; Borego Valley, *F. Youngberg 81* (P).

8. **Nemacladus rubescens** var. **interior** (Munz) comb. nov.

N. rigidus var. *interior* Munz, Amer. Journ. Bot. 11:243. 1924. Type locality: "North Fork, Peckinpah, Fresno Co." (Madera Co., according to maps), Calif. Type: *K. Brandegee*, in 1911; in the herbarium of Pomona College.

Plants resembling those of typical *N. rubescens* but taller and more strict, (7.0) 15 to 25 (32) cm. tall, the branches rather stiff and strongly ascending. Stems brownish or purplish, dull or somewhat shining, never with a silvery-gray sheen.

Leaves similar to those of typical *N. rubescens*, but with mostly irregularly serrate margins, green to brownish or purplish when dry, rarely yellow. Blades 0.2 to 0.5 cm. wide by 0.4 to 2.2 cm. long, usually about twice as long as wide, narrowed gradually to a margined petiolar base or abruptly to a distinct petiole which may be 0.3 to 0.5 cm. long. Pubescence almost none; rarely a few hairs along the margins and on the upper surface near base.

Pedicels usually conspicuously ascending, mostly forming an angle of 60° or less with the stem, stiff and straight or essentially so or curved near the end, 7.0 to 13.0 (17.0) mm. long, about as thick as those of typical *N. rubescens*, usually somewhat ciliate on upper side near base. Flower-bracts linear to lanceolate, blunt, often slightly ciliate on margin, 1.0 to 3.0 (6.0) mm. long, scarcely or not at all enfolding the pedicel.

Calyx turbinate or obconic in anthesis and in fruit, the base acute and narrowing rather gradually into the pedicel. Capsule about half inferior, 1.3 to 2.0 mm. in diameter by 2.0 to 3.5 mm. long, the free part rounded or obscurely pointed and containing more seeds than the narrow basal portion which is adherent to the calyx tube. Calyx-lobes as in typical *N. rubescens*, 0.7 to 1.3 (1.5) mm. long.

Corolla "pale lilac, blotched red-violet" *(Keck 1175)* or "white, pink-tinged on backs of lobes; each of the 3 lobes of the upper lip with transverse

wine-red band near base and tint of yellow below the band" *(Carlotta C. Hall 192)*, the lobes without ciliation on margin. Corolla (2.0?) 2.5 to 5.0 mm. long, the lobes nearly free, spreading. Filament-tube 1.8 to 3.0 mm. long, appearing conspicuously exserted, somewhat curved above, glabrous throughout. Appendages similar to those of *rubescens*, but the terminal cells shorter, about 0.4 mm. in length and equalling the stipe. Anthers 0.5 to 0.8 mm. long, often purplish.

Seeds like those of typical *N. rubescens* in size and shape. Surface of seed usually plainly pitted, the 10 to 12 rows of pits with 8 to 10 pits in each row.

Dry gravelly or rocky slopes along the western slopes of the Sierras from northern California (Oregon?) south to Kern County. A mountain species, ascending to at least 1800 meters, but most abundant at altitudes of 700 to 1500 meters.

Collected in flower and fruit mostly from May 15 to July 15.

By virtue of the same reasoning as that set forth above in the discussion of *N. rubescens*, the present plant is almost certainly not closely related to *N. rigidus* Curran. It is, however, indistinguishable from the typical *rubescens* except for differences in stem-color and leaf-color, minor differences in position of the pedicels and branches, and moderate differences in shape of the capsule. It is thus considered by the present author as a variety of *N. rubescens*. Additional field-work in the region where the two varieties grow close together (centering about Kern, Inyo and Tulare Counties, California) may or may not substantiate this view. It is quite possible that one would be justified in maintaining this plant of the western slopes of the Sierras as a separate species, as its range is quite distinct from that of typical *N. rubescens* (possibly overlapping in Kern County, but so far as known, not elsewhere). No actual intermediates have been seen, although any series of specimens may show intergrading of a single character. *Hall & Chandler 6819*, collected at Kane Spring, Ord Mts., San Bernardino Co., has exactly the habit of typical *N. rubescens*, combined with the stem color, pedicels and leaves of var. *interior*.

The variety here discussed is identical with *N. rigidus* var. *interior* of Munz' revision, so that only the following additional specimens are cited:

CALIFORNIA: *T. Bridges 146* (ELG, NB, US). LOS ANGELES; Mohave Desert, *G. B. Grant 4373* (NB); MONTEREY; Tassajara Hot Springs, *A. D. E. Elmer 3350* (CalAc). SAN BERNARDINO; San Bernardino, *Lemmon Herb.*, May, 1878 (US); SAN LUIS OBISPO; *Lemmon Herb.*, without locality, ann. 1887-1888 (UC). STANISLAUS; 12 mi. e. of Waterford, *R. F. Hoover 1106* (UC). BUTTE; Enterprise, *Elisha Brooks*, without date (CalAc,UC).

OREGON: Without locality, *Miss Dix*, in 1888 (Mo). This specimen, cited by Munz, is undoubtedly the variety in question, but in view of the lack of data accompanying it and the considerable range extension which it represents, there may be a question as to the actual source of the material.

9. *Nemacladus glanduliferus* Jepson, Man. Fl. Pl. Calif. 975. 1925. Type locality: Wagon Wash near Sentenac Canyon, western Colorado Desert, Calif. Type: *W. L. Jepson 8766;* presumably in the personal her-

barium of W. L. Jepson; not seen. Isotype seen in the herbarium of Pomona College.

Not easily distinguished from the more widespread var. *orientalis* by vegetative characters, but usually with more flexuous branches than the latter, the branches often intricately entangled in dried material.

Rosette-leaves usually oblanceolate, obtuse, gradually narrowed to a winged base; blades usually strongly toothed or pinnatifid, glabrous or nearly so.

Pedicels widely spreading at base, mostly leaving the stem at an angle of 60° to 90°, often bowed upward near base, usually curved abruptly near tip so that the flower and fruit are stiffly erect. Fruiting pedicels 7 to 13 mm. long, smooth and glabrous, slender but not capillary, distinctly thicker than a coarse Caucasian human hair. Flower bracts linear to lanceolate, glabrous or ciliate on the margins, blunt at tip, 2 to 5 mm. long, flat or somewhat folded at base, often wide-spreading or reflexed and scarcely concealing (or even enfolding) the base of the pedicel.

Calyx in anthesis mostly broadly rounded at base, becoming hemispheric in fruit. Capsule about half inferior or a little less, 2.0 to 2.3 mm. in diameter by 2.2 to 3.0 (4.0) mm. long, acute at tip. Calyx-lobes linear or narrowly triangular, acute, (1.3) 1.5 to 2.5 (4.5) mm. long.

Corolla about as in var. *orientalis*. Filament-tube 1.6 to 2.3 mm. long, glabrous, the tip curved. Appendages apparently always lacking. Anthers 0.2 to 0.35 mm. long.

Seeds indistinguishable from those of var. *orientalis*.

Sandy and gravelly soils of gullies and washes, on desert, from southern San Bernardino County, California, south to northern Baja California. Most of the collections in herbaria are from western part of the Colorado Desert, at altitudes of 300 to 600 meters.

Collected in flower and fruit from March 24 to May 18.

This is one of a group of related plants having small flowers and longitudinally impressed-striate seeds which must take the name proposed by Jepson for a specimen from the western Colorado Desert, California. The type, *Jepson 8766*, is from Wagon Wash, near Sentenac Canyon, San Diego County. It agrees in every particular with the series of specimens designated as series 2 under the discussion of *N. pinnatifidus* (p. 530 above). Conspecific with these plants are those designated above as comprising series 1 under the discussion of *N. rubescens*. Also conspecific with both the above is the plant described by Munz as *Nemacladus rigidus* var. *australis*. Although Munz' name antedates Jepson's by a year, the first specific epithet must be taken up for the whole group.

The three plants mentioned in the above paragraph have been poorly understood. *N. glanduliferus* proper has been merged, its presence unsuspected, with the plant here called *N. pinnatifidus*. The varieties *orientalis* and *australis* have been treated as varieties of *N. rigidus*, or, in the case of the former, the name *N. rubescens* has been used. As partially explained above, these three plants are quite distinct from the rest of the genus by virtue of

their peculiarly impressed seeds. In the opinion of the writer, these differences are of sufficient magnitude to establish the identity of this specific group and to separate it sharply from the group of *N. rigidus*, which may be similar in plant-habit or in aspect of corolla. The group of *N. glanduliferus* is easily separated from the varieties of *N. rubescens* by the seed-characters and by the size of the flowers as well. The only species having seeds similar to those of *N. glanduliferus* and its varieties is *N. montanus* Greene, which is here considered to be distinct by virtue of its disjunct range and much larger flowers and seeds.

Specimens Examined: BAJA CALIFORNIA: La Grulla, *C. R. Orcutt*, May 18, 1886 (NB).

CALIFORNIA: Colorado Desert, *T. S .Brandegee*, April, 1905 (UC, US); Wagon Wash, near Sentenac Canyon, Colorado Desert, *Jepson 8766* (P); Choia (Cholla?) Ranch, *M. E. Jones*, April 19, 1906 (P). IMPERIAL; between Coyote Wells and Cement Bridge, *E. A. McGregor 845* (S). RIVERSIDE: Dry Morongo Valley, *Munz 11922* (P); Painted Canyon, Colorado Desert, *J. T. Howell 3535* (CalAc); Shaver's Well, near Mecca, *Munz & Keck 4745* (P); S. Base of Eagle Mts., 3 mi. n.e. of "The Hayfields," *Munz & Keck 4824* (P). SAN BERNARDINO; Sheephole Mts., southern Mohave Desert, *Munz 13807* (UC); San Bernardino, *S. B. & W. F. Parish 831* (NB). SAN DIEGO; Mountain Palm Spring, *Munz & Hitchcock 12103* (P, S, UC); Borego Valley, *F. Youngberg 81* (P); Palm Canyon, Borego Valley, *Munz & Hitchcock 11333* (G, P) and *11334* (P); Borego Palm Canyon, *F. Youngberg 113* (P); 6 mi. e. of Jacumba, *Munz 8078* (P); Box Canyon, western Colorado Desert, *Munz & Hitchcock 12039* (P); southwestern part of Colorado Desert, *C. R. Orcutt*, April 15-25, 1889 (G, US); San Felipe Hill (Co.?), *M. E. Jones*, April 19. 1906 (P, S); San Felipe Creek, Colorado Desert, *A. Eastwood 2702* (CalAc, G, NB, US).

10. **Nemacladus glanduliferus** Jepson, var. **australis** (Munz) comb. nov.

N. rigidus var. *australis* Munz, Amer. Journ. Bot. 11:242. 1924. Type locality: Rosario, Baja California. Type: *C. R. Orcutt 1348*, May 1, 1886; in the Gray Herbarium.

A plant of uncertain status, known only from the type collection. It differs from typical *N. glanduliferus* by its much stouter and shorter stems, which rarely exceed 5.0 cm. in height, by its more diffuse plant-body, its stouter pedicels and its somewhat larger capsules, which average 3.5 to 4.0 mm. in length. The staminal appendages are essentially like those of var. *orientalis* but with the terminal cells less sharply reflexed.

The plants are superficially very similar to those of *N. rigidus*, but the seeds and flower-characters agree exactly with the other varieties of *N. glanduliferus*.

Habitat unknown. Known only from Rosario, Baja California.

Collected in fruit, May 1, 1886.

Specimens Examined: BAJA CALIFORNIA: Rosario, *C. R. Orcutt 1348* (CalAc, ELG, G, P, UC).

11. **Nemacladus glanduliferus** Jepson, var. **orientalis** var. nov.

Type locality: Shore of Lake Mead, near Boulder Dam, Clark Co., Nevada. Type: *Percy Train 1566*, May 2, 1938; no. 52430 of the herbarium of the National Arboretum.

N. ramosissimus of Torrey, Bot. Mex. Bound. Surv. 108. Pl. 35. 1859.

N. rigidus var. *rubescens* (Greene) Munz, Amer. Journ. Bot. **11**:245. 1924, in part.

Planta erecta, ramibus pedicellisque adscendentibus, plerumque rigidis; corolla quinque-partita fere ad basin; lobis calycis 1.0-1.6 mm. longis; seminibus longitudinaliter impressis, striatis, non foveatis.

Branches usually ascending and rather stiff, but occasionally loose and flexuous. Plants 5 to 15 (25) cm. tall. Stems pubescent below and sometimes in the axils of the bracts, or essentially glabrous, dull or slightly lustrous, brownish or purplish, at least below.

Rosette-leaves few to 20, usually oblanceolate but sometimes elliptic, usually obtuse at tip and narrowed gradually to a broadly winged base (leaves with elliptic blades often with a distinct slender petiole). Leaf-blades usually toothed (sometimes obscurely so) or pinnatifid, green to brownish or purplish when dry, 0.1 to 0.3 cm. wide by 0.3 to 1.6 cm. long, usually 3 to 6 times as long as wide. Pubescence of leaves present near base only (on margins and upper side of blade) or almost wanting.

Pedicels usually conspicuously ascending, mostly forming an angle of 60° or less with the stem, characteristically stiff and straight but sometimes curved upward near the tip. Fruiting pedicels 6.0 to 11.0 (16.0) mm. long, slender but not at all capillary, two or more times as thick as a coarse Caucasian human hair, usually ciliate on upper side near base. Flower-bracts lanceolate to ovate, glabrous or ciliate on the margins, blunt at tip, 1.0 to 3.0 (6.0) mm. long, somewhat conduplicate and enfolding the base of the pedicel, but usually not completely concealing it.

Calyx turbinate, the tube somewhat enlarged above; fruiting calyx cup-shaped, somewhat acute at base. Capsule $^1/_3$ to $^1/_2$ inferior, acute at tip, 1.5 to 2.0 mm. in diameter by 2.0 to 2.5 (3.5) mm. long. Calyx-lobes linear to elliptic or narrowly deltoid, 1.0 to 1.6 mm. long, subacute.

Corolla white (?), some or all of the lobes with purplish tips; margins of at least the three upper lobes usually ciliate. Corolla (1.3) 1.5 to 2.2 (2.6) mm. long, the tube 0.5 mm. long or less, spreading, much exceeded by the spreading lobes. Filament-tube 1.2 to 1.7 (2.0) mm. long, equalling or slightly shorter than the corolla, appearing exserted because of the spreading corolla, usually curved near tip, smooth and glabrous throughout. Appendages with terminal cells sharply reflexed, clavate, about equalling the stipe, slightly less than 0.5 mm. in length. Anthers 0.2 to 0.3 (0.4) mm. long.

Seeds varying from cylindrical, with perfectly straight sides and truncate ends, to somewhat ellipsoid; length 0.6 mm. or less; each seed divided into 6 to 8 longitudinal ridges separated by sharply impressed lines; each longitudinal ridge divided by fine transverse lines into 15 to 20 (30?) narrow cross ridges.

Open desert sand, sandy washes, sandy and gravelly banks; deserts and mountains bordering on deserts; apparently most abundant at middle altitudes in mountains, from 600 to 1500 meters. The most widely distributed of any of the species or varieties of *Nemacladus*, occurring from Inyo and Los Angeles Counties, California, south and east to northern Baja California, northern

Sonora, southern and western Arizona and southwestern Utah. It probably occurs in southwestern New Mexico and northern Chihuahua.

Collected in flower and fruit mostly from March 15 to May 15.

This variety, the most widely distributed member of the genus, grades into the typical form of the species but can usually be distinguished from it by the straighter pedicels, which are often stiffly spreading in var. *orientalis*, and by the somewhat shorter calyx-lobes. The range of var. *orientalis* overlaps those of at least four other species, particularly along the western edge of the Mohave Desert, and two or more of these are frequently collected in the same locality and mounted on the same herbarium sheet under the same name. If mature seeds are available, *N. glanduliferus* var. *orientalis* is at once separable from any associated species. Lacking mature seeds and capsules, this variety may be distinguished from *N. gracilis* by its stiff pedicels and much more deeply divided corolla, as well as by the quite different appendages of the stamens. Its stiff pedicels and small flowers separate it from the varieties of *N. rubescens*, as does its purplish (not silvery) stem. *N. ramosissimus*, which ranges north and east to the southwestern corner of San Bernardino County, is easily distinguished by its capillary pedicels, long lax bracts and non-zigzag stems.

The distribution of this variety is fairly well known as far as the western and northern limits of its range are concerned. In Mexico, however, few stations are known for it, although it has been found in Baja California, and in Sonora. The localities ascribed to New Mexico, including those of Charles Wright and of Parry, are in some doubt, and may actually have been in Sonora or Chihuahua. No authentic records are available for New Mexico or Chihuahua, although the plant very probably occurs in both states, and possibly also is to be found in extreme western Texas.

Specimens Examined: CALIFORNIA: Mohave Desert, *K. Curran*, in 1884 (G, P); Mohave Desert, *J. G. Lemmon* in 1884 (ELG); Piute Creek, *N. C. Wilson*, June 6, 1893 (UC); Greenwater Flat, Mohave Desert, *S. B. Parish 9879* (S). IMPERIAL; 25 mi. n.e. of Ogilby, *Munz & Hitchcock 12178* (P, S, UC). INYO; Funeral Mts., Death Valley, *M. E. Jones*, April 10, 1907 (P); Bishop, Owen's Valley, *M. E. Jones*, May 15, 1897 (P); 12 mi. s.w. of Shoshone, *C. L. Hitchcock 12308* (P); between Stewart's Valley and Shoshone, *R. S. Ferris 7366* (NB, S); 5 mi. n. of Bradbury's Well, *F. R. Fosberg S414* (UP); Bradbury's Well, Mohave Desert, *C. L. Hitchcock 12355* (P, S); 4 mi. s. of Bradbury's Well, *Munz & Hitchcock 10979* (P) and *10980* (P); Bradbury's Well, *Munz 14894* (P); Black Mts., 2 mi. e. of Bradbury's Well, *J. T. Howell 3641* (CalAc); Keanes Spring, Amargosa Range, *Munz 12578* (P, UC); Panamint Mts., *Coville & Funston 677* (ANS, G, NB, US); Pleasant Canyon, Panamint Mts., *Hall & Chandler 6996* (UC); Darwin, Argus Mts., *M. E. Jones*, May 10, 1897 (P). LOS ANGELES; Los Angeles, *M. E. Jones*, August, 1884 (ANS, CalAc, NB, S, UC). RIVERSIDE; Corn Springs, Chuckwalla Mts., *Munz & Keck 4852* (P, UC); "Hayfields," *M. E. Jones*, April 2, 1930 (P). SAN BERNARDINO; near Watermans and Calico, Mohave Desert, *J. G. Lemmon 3132*, May 10-12, 1884 (Cath, G, P); 10 mi. north of Riggs, Mohave Desert, *Munz & Hitchcock 10948* (G,P); Kramer, *K. Brandegee*, May, 1913 (CalAc, G, NB, P, UC); Barstow, *K. Brandegee*, May 14-15, 1905 (P, UC); Panamint Canyon, *M. E. Jones*, May 3, 1897 (P) and May 4, 1897 (NB, P, US); vicinity of Bonanza King Mine, Providence Mts., *Munz et al. 4230* (P); Needles, *Munz & Harwood 3643* (P); Newberry Mts., 10 mi. e. of Daggett, *Munz & Keck 7859* (P); Kelso, *M. E. Jones*, May 2,

1906 (P, S); Vontrigger Spring, *Munz 13680* (P, S, UC); Twenty-nine Palms, *M. E. Jones*, April 15, 1927 (P); "in aridis arenosis pr. Barstow," *M. F. Spencer 1940* (ANS, G); Newberry Springs, Mohave Desert, *Wiegand & Upton 4350* (NB); Parker Cutoff, 29 mi. from Needles, *R. S. Ferris 7231* (NB, S); 4 mi. from Parker on Needles Rd., *R. S. Ferris 7726* (S); Morongo Valley, *A. Eastwood 18680* (CalAc); Sheep Hole Mts., *H. M. Hall 6046* (UC); Sheep Hole Mts., *Munz 13807* (P); Kane Spring, Ord Mts., Mohave Desert, *Hall & Chandler 6819* (UC); Granite Mts., 16 mi. e. of Victorville, *F. R. Fosberg S2519a* (UP). SAN DIEGO: 6 mi. e. of Jacumba, *Munz 8078a* (P).

NEVADA: Mica Spring, 4000 ft., *M. E. Jones 5045u* (US). CLARK: Eldorado Canyon at Nelson, *M. E. Jones*, April 30, 1907 (P); Good Springs, *M. E. Jones*, April 30, 1905 (P); Moapa, *P. B. Kennedy 1079* (US); Moapa, *L. N. Goodding 2211* (G); Las Vegas, *L. N. Goodding 2319* (NB, UC); shore of Lake Mead, near Boulder Dam, *P. Train 1566* (NatArb); 3 mi. w. of Nelson, *LaRivers & Hancock 100* (NatArb). NYE: Rhyolite, *M. E. Jones*, April 25, 1907 (P).

ARIZONA: Chimehuevis, *M. E. Jones*, April 21, 1903 (P); Castle Creek, *J. W. Toumey 459* (US); Pierce Springs, *M. E. Jones 5077ae* (P, US); Sabina Cañon, *Miss Myrtle Zuck*, April 4, 1896 (US); Montezuma Castle Nat'l Monument, *A. & R. A. Nelson 2041* (NB); "Rio Gila near Pimos Villages," *C. C. Parry*, in 1852 (Torrey herb., NB); without loc., *W. F. Parish 138* (S); "Central Arizona," *E. Palmer 300* (ANS). GILA: 12 mi. n. of Roosevelt, *Peebles & Smith 11507* (US); road to Amethyst Mine, Mazatzal Mts., *A. Eastwood 17112* (CalAc); Mercury Mine, Mazatzaal Mts., *A. Eastwood 16891* (CalAc). GRAHAM: Tanque, *W. W. Eggleston 19888* (US). GREENLEE: Clifton, *A. Davidson 91* (S, US). MARICOPA: Phoenix, *A. Eastwood 6176* (CalAc); s.e. base of Salt River Mts., *J. W. Gillespie 5524* (S, UC, US); 11 mi. e. of Gila Bend, *M. E. Jones 29215* (P) and *M. E. Jones*, April 10, 1932 (P); Wickenberg, *M. E. Jones*, May 5, 1903 (P). MOHAVE: Yucca, *M. E. Jones 3920* (P, US); Peach Springs, *E. L. Greene*, July 2, 1889 (ELG); Peach Springs, *M. E. Jones*, May 26, 1904 (P); Beaver Dam River, Arizona Strip, *B. Maguire et al. 5006* (P, UC). PIMA: Tucson, *J. W. Toumey 217* (US); Hills east of Vail, *R. H. Peebles 11371* (CalAc, P); 8 mi. n. of Vail, *F. R. Fosberg 7896* (P, UC); Covered Wells, *Sister Th. Marie Burnham 245* (Cath); Tucson, *David Griffiths 2425* (NB); Tucson, *Dr. Smart* (US); mesas near Tucson, *C. G. Pringle*, April 25, 1884 (ANS, NB); Papago Reservation, *Peebles et al. 3755* (US). PINAL: Sacaton, *R. H. Peebles 6595* (NB) and *Loomis & Peebles 965* (P); San Ton Mts., *Peebles 11306* (NB, US); San Ton Mts., 16 mi. n. of Casa Grande, *G. J. Harrison 3879* (P). YUMA: Tule Mts., *Kearney & Peebles 10887* (CalAc, P); 8 mi. e. of Quartzite, *I. L. Wiggins 6644* (S, US); Mohawk, *T. H. Kearney 3919* (P, US); Harcouvar Mts., *R. H. Peebles 8517* (G); Plomosa Mts., *Kearney & Peebles 10989* (US).

UTAH: WASHINGTON: St. George, *M. E. Jones*, April 15, 1880 (G, P); Valley of the Virgin near St. George, *C. C. Parry 143* (ANS, G, NB, US).

NEW MEXICO: Valley of the Rio Grande below Doñana, *Parry et al.* (Mex. Bound. Surv. 695) (ANS, US); without loc., *Charles Wright 1431* (ANS, G, NB, UC, US).

SONORA: Stony hills near Frontera, *C. Wright* in 1852 (CalAc, NB); "west of El Paso," *C. C. Parry* in 1852 (ANS); 6 mi. s. of Magdalena, *L. R. Abrams 13219* (S); 4 mi. w. of Caborca, *D. D. Keck 4031* (US).

BAJA CALIFORNIA: La Grulla, *C. R. Orcutt*, May 18, 1886 (NB, UC).

12. *Nemacladus montanus* Greene, Bull. Calif. Acad. 1:197. 1885. Type locality: Allen's Springs, Lake Co., Calif. Type: *D. Cleveland* in 1882, no. 54593 of the herbarium of the California Academy of Sciences.
N. rigidus var. *montanus* (Greene) Munz, Amer. Journ. Bot. **11**:243. 1924.

Branches several-times forked, stiffish and strongly ascending, the habit almost exactly that of *N. rubescens* var. *interior*. Plants 10 to 18 cm. tall, the stems brownish or purplish, somewhat lustrous, glabrous or essentially so.

Leaves entire or obscurely toothed, oblanceolate, or elliptic with a petiolar base, the blades 0.2 to 0.5 cm. wide by 0.6 to 1.8 cm. long; pubescence of leaves almost none.

Pedicels conspicuously ascending, about as in *N. rubescens* var. *interior* in position and thickness, 12 to 15 mm. long, usually ciliate on upper side near base (stem also ciliate in axil opposite pedicel). Flower-bracts linear to lanceolate, blunt or subacute, 1.0 to 3.0 mm. long, scarcely or not at all enfolding the pedicel.

Calyx in anthesis turbinate, often oblique, in fruit enlarging somewhat and with the tube distended unequally by the seeds, the base narrowing gradually into the pedicel. Capsule about half inferior, blunt-pointed, 1.5 to 2.0 mm. in diameter by 2.5 to 3.0 mm. long. Calyx-lobes 1.2 to 1.6 mm. long, blunt.

Corolla white or purplish, 1.5 to 2.5 mm. long, the lobes free nearly to the base. Filament-tube 2.0 to 2.5 mm. long, glabrous, usually somewhat curved above. Appendages indistinguishable from those of *N. rubescens* var. *interior*. Anthers 0.6 to 0.7 mm. long.

Seeds ellipsoid, varying from fusiform to nearly as wide as long, 0.8 to 0.9 mm. long, each divided by sharply impressed longitudinal lines into 10 to 12 broad ridges; each longitudinal ridge divided by fine transverse lines into about 30 narrow cross ridges.

Habitat unknown. Known only from the mountains of Lake County and Napa County, California.

Collected in fruit from June 15 to June 25.

This is perhaps the most restricted in range of any member of the genus. In Greene's original description it was attributed to "Mountain districts of the central portions of the State: Butte County, Elisha Brooks; Lake County, D. Cleveland; Yo Semite Valley, Mrs. Curran."

The "type" material in the herbarium of the California Academy of Sciences comprises, upon examination, three distinct entities. The Brooks specimen from Enterprise, Butte Co. (Cal. Acad. 54595), is *N. rubescens* var. *interior;* the seeds are exactly those of this variety. Mrs. Curran's collection on the type sheet (Cal. Acad. 54594) is marked "Foothills of Sierra Nev., 1883" and consists of two plants, one of which is typical *N. rubescens*. The second plant is lacking mature fruit, but has larger flowers and more seeds per capsule than any specimen of true *N. montanus* examined by the writer and is almost surely *N. rubescens* var. *interior*. A sheet in the Gray Herbarium, marked "Nemacladus montanus Greene" and "Yo Semite Valley" by Dr. Greene, collected by M. K. Curran in 1883, is *N. rubescens* var. *interior;* this is probably the collection referred to in Greene's original description. The Cleveland collection (Cal. Acad. 54593) is marked "*N. montanus*" in what appears to be Dr. Greene's hand. It is without locality or other data, but has

the seeds of the original description: "large, ovate-oblong, with longitudinally compressed zigzag reticulation." Greene also notes that "In respect to the paucity of the seeds the species is like *N. capillaris*, but the reticulation of them is widely different." This last appears to be a fairly good diagnostic character, the number of seeds in *N. rubescens* var. *interior* being somewhat greater than that in *N. montanus*.

The type specimen of *Nemacladus montanus* Greene may be designated as follows: Specimen no. 54593 of the herbarium of the California Academy of Sciences, collected by D. Cleveland, presumably in Lake County, California. Additional material, no doubt from the same collection, exists in the Gray Herbarium and the herbarium of the University of California.

As in the case of the other species and varieties considered by the writer to be distinct from *N. rigidus* Curran, the present species appears to be separated by good seed and flower characters. Its combination of large flowers and characteristically impressed-lined large seeds, together with its restricted range, sets it quite apart from all the other members of the genus. There seems to be no justification for considering it either a variety of *N. rigidus* or a variety of *N. rubescens*.

Specimens Examined: CALIFORNIA: LAKE; Allen's Springs, *D. Cleveland*, June 25, 1882 (CalAc 54593; Type, G, UC). NAPA; mountains of Napa County, *Cornelia S. Masters*, June 15, 1915 (CalAc); 4 mi. n. of Knoxville Mines, *H. L. Mason 10000* (CalAc, Cath, NB, P, S, UC, US); Pope Creek Bridge S. of Walters Springs, *D. D. Keck 2349* (S).

13. *Nemacladus rigidus* Curran, Bull. Calif. Acad. 1:154. 1885. Type locality: "Geiger Grade, near Virginia City, Nevada." Type: *K. Curran*. July, 1884, no. 110961 of the herbarium of the University of California, labelled "Geiger Grade, near Steamboat Springs, Nevada."

Stems simple or sparingly forked, mostly spreading-decumbent, fruiting to the base of the plant or nearly so. Plants (2.0) 4.0 to 9.0 (13.0) cm. tall. Stems sparsely pubescent, especially below, somewhat lustrous, purple.

Rosette-leaves 5 to 7, elliptic, narrowed to the blunt tip and the broad petiolar base (or sometimes with a suggestion of a division into an ovate blade and a broad petiole), green or purplish when dry. Blades 0.2 to 0.4 cm. wide by 0.8 to 1.0 cm. long. Pubescence of leaves sparse, mostly confined to margins of petiole and to upper (adaxial) side near base.

Pedicels spreading, leaving the stem at an angle of 60° to 90°, stiff and straight. Fruiting pedicels 8 to 11 mm. long, sometimes as much as 0.3 mm. in diameter, smooth or ciliate near base. Flower bracts broadly elliptic, foliaceous, smooth or ciliate on the margins, rounded at tip, 2.0 to 3.0 mm. long by as much as 1.0 mm. wide, flat or somewhat rounded on back at base, not surrounding nor concealing the base of the pedicel.

Calyx in anthesis short-campanulate, mostly rounded at base, in fruit much enlarged and often oblique. Capsule about half inferior, acute at tip, 2.0 to 2.5 mm. in diameter by 3.0 to 4.0 mm. long. Calyx-lobes lanceolate to ovate,

somewhat foliaceous, strongly unequal in size, the larger ones 1.0 to 1.3 mm. across by 1.5 to 2.5 mm. long, blunt or subacute.

Corolla purplish, 1.0 to 1.5 mm. long, the tube very short, 0.2 to 0.3 mm. long. Filament-tube 1.0 to 1.3 mm. long, glabrous, slightly curved or straight. Appendages minute, reflexed, the few terminal cells clavate. Anthers 0.2 to 0.3 mm. long.

Seeds ellipsoid, about 0.75 mm. long, each with 8 to 10 narrow longitudinal ridges and rows of about 15 narrow pits between the ridges.

Habitat "Sandy hillsides," "hillsides." Southeastern Oregon to Lassen County, California and southern Washoe County, Nevada.

Collected in flower and fruit from May to July.

Nemacladus rigidus is easily recognized by its short, stout stems, its relatively large capsules and its very short corolla. In appearance it is simulated by *N. glanduliferus* var. *australis* but the latter is readily distinguished by its characteristic seeds and by its larger corolla. Because of the similarity of the stamens and corolla of *N. rigidus* to those of *N. capillaris* Greene, the writer has hesitated to disagree with Munz in his treatment of the latter as a variety of the former. In geographic range, however, the two plants appear not to overlap. In addition to this, there appear to be absolutely no intermediates between them; *N. capillaris* is invariably characterized by a short, rounded, few-seeded capsule and by slender stems and pedicels; *N. rigidus*, on the other hand, always has the enlarged, pointed, many-seeded capsule and the stiff short stems which gave it its name. Because of the above evidence from morphology and geographical distribution, the most suitable course seems to be to treat the two as independent species.

N. capillaris is not readily confused with any other species when in fruit, as its short, rounded, few-seeded capsule, with a narrow tapering base, is unlike that of any other member of the genus. In flower it may be mistaken for small-flowered forms of *N. gracilis*, from which it may usually be distinguished by its deeply divided corolla, its stiffer and straighter pedicel, its scarcely (or not at all) clasping flower-bracts and its more pointed calyx.

N. rigidus as here understood is exactly that of Munz' revision.

Specimens Examined: CALIFORNIA: LASSEN; 4 miles s. of Omira, *J. T. Howell 11845* (CalAc). MODOC; Surprise Valley near Lower Lake, *Miss S. A. Plummer*, May 1879 (G).

NEVADA: WASHOE; Reno, *F. H. Hillman*, without date (P); Reno, *M. K. Curran*, July 1884 (ANS); Reno, *C. F. Sonne*, June 8, 1890 (ELG, UC); between Reno and Verdi, *C. F. Sonne*, June 1890 (UC); between Reno and Virginia, *M. K. Curran*, July, 1884 (CalAc, G); n. of Verdi, *Heller 10893* (ANS, G, NB); Verdi, *C. F. Sonne*, May 20, 1888 (ELG); Geiger Grade near Steamboat Springs, *K. Curran*, July, 1884 (UC; Type).

OREGON: HARNEY; 3 miles n. of Alvord Ranch, *M. E. Peck 14006* (WU); 10 miles s. of Narrows, *M. E. Peck 18954* (WU). LAKE; Paisley, canyon of Chewaucan River, *M. E. Peck 15654* (WU). MALHEUR; near Harbor Ranch, *J. B. Leiberg*

2113 (ANS, CalAc, G, NB, P, UC); hillsides of the Malheur, *W. C. Cusick 1625* (G, ELG, UC).

14. *Nemacladus capillaris* Greene, Bull. Calif. Acad. 1:196. 1885. Type locality: Mohave Desert, California. Type: *M. K. Curran* in 1884, no. 54590 of the herbarium of the California Academy of Sciences.

Nemacladus rigidus var. *capillaris* (Greene) Munz, Amer. Journ. Bot. **11**:244. 1924.

Branches few- to several-times forked, usually rather stiffly ascending. Plants (5.0) 7.0 to 15.0 (18.0) cm. tall. Stems wholly glabrous or minutely pubescent, somewhat lustrous, brownish or purplish.

Rosette-leaves mostly 6 to 8, usually ovate, acute or blunt at tip, narrowed rather abruptly at base to a definite short, broad petiole 0.2 to 0.4 cm. long; blades obscurely crenate or entire, green to brown or purplish when dry, 0.15 to 0.6 cm. wide by 0.3 to 1.5 cm. long, mostly 1.25 to 2.5 times as long as wide. Pubescence of leaves usually wanting.

Pedicels spreading or ascending, rather weak and lax but characteristically straight and ordinarily without a definite or symmetrical curve, so that the flower and fruit are not strongly upturned. Fruiting pedicels (6.0) 8.0 to 12.0 (15.0) mm. long, slender to almost capillary, smooth and glabrous. Flower-bracts elliptic to narrowly ovate, smooth and glabrous, blunt at tip, 1.0 to 2.5 (3.0) mm. long, flat or slightly folded at base, but not at all or scarcely surrounding the base of the pedicel.

Calyx turbinate in anthesis and in fruit; fruiting calyx acute at base. Capsule about half-inferior, the free part rounded; base narrow, very few-seeded. Capsule 1.0 to 1.5 mm. in diameter by 1.5 to 2.7 mm. long. Calyx-lobes elliptic or obtusely triangular, blunt, 0.6 to 1.2 (1.5) mm. long.

Corolla white (?), 0.7 to 1.3 mm. long, the tube almost none. Filament-tube (0.6) 0.8 to 1.2 mm. long, smooth and glabrous, slightly curved at tip. Appendages minute, reflexed, scarcely 0.1 mm. in length. Anthers 0.2 mm. long or slightly less.

Seeds broadly ellipsoid, 0.5 to 0.75 mm. long with 8 to 10 low narrow longitudinal ridges and rows of 9 to 12 shallow pits between the ridges.

Dry or sterile soil, often in partial shade (chaparral) or in recent burns or clearings or along roadsides, at various altitudes up to at least 1200 to 1400 meters. A plant reaching its best development in northern California; range from southwestern Oregon south in the Coast Ranges and along the western slopes of the Sierras to Santa Clara and Merced Counties, California, and sparingly to the Mohave Desert.

Corolla white (?), 0.7 to 1.3 mm. long, the tube almost none. Filamentation from Colton, San Bernardino Co., *Jones 3395* (CalAc, NB, P) was made

April 29, 1882, and a collection from San Bernardino, made by Lemmon, is dated May, 1878 (Cath).

The plant here discussed is identical with *N. rigidus* var. *capillaris* of Munz' revision, where a full list of exsiccati may be found. The following additional specimen may be cited:

OREGON: JACKSON; 26 mi. e. of Ashland, near Pinehurst, on Ashland-Klamath Falls road, *M. E. Peck 9293* (G, WU).

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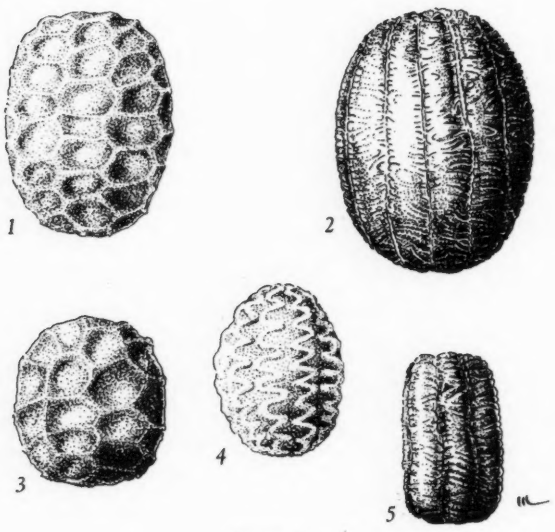

PLATE 1

FIGURES

1. Seed of *Nemacladus pinnatifidus*, x50.
2. Seed of *Nemacladus montanus*, x50.
3. Seed of *Nemacladus ramosissimus*, x50.
4. Seed of *Nemacladus rubescens*, x50.
5. Seed of *Nemacladus glanduliferus* var. *orientalis*, x50.

The writer acknowledges with gratitude the assistance of Mr. B. Y. Morrison, who made the drawings of seeds reproduced in Plate 1.

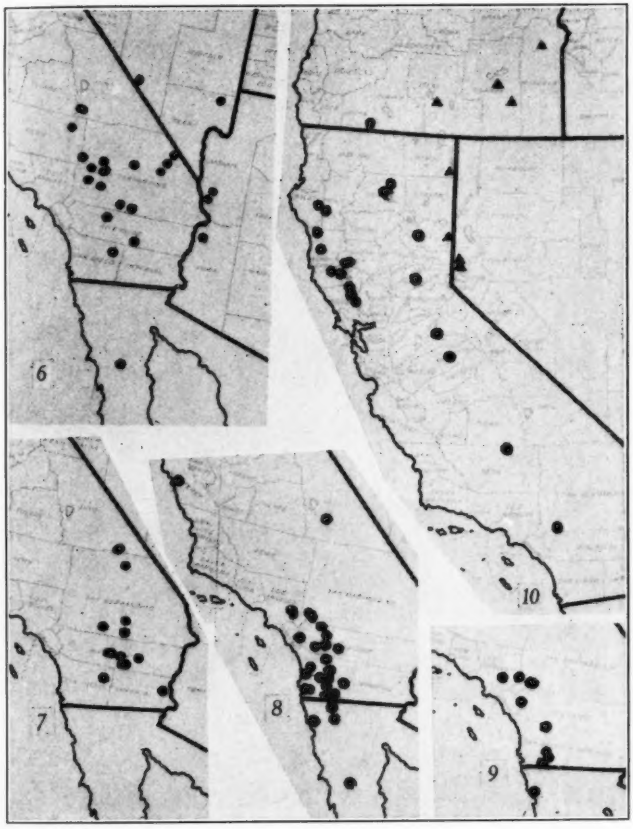

PLATE 2

FIGURES

6. Distribution of *Nemacladus rubescens*.
7. Distribution of *Nemacladus rubescens* var. *tenuis*.
8. Distribution of *Nemacladus ramosissimus*.
9. Distribution of *Nemacladus pinnatifidus*.
10. (Circles)—Distribution of *Nemacladus capillaris*; (Triangles)—Distribution of *Nemacladus rigidus*.

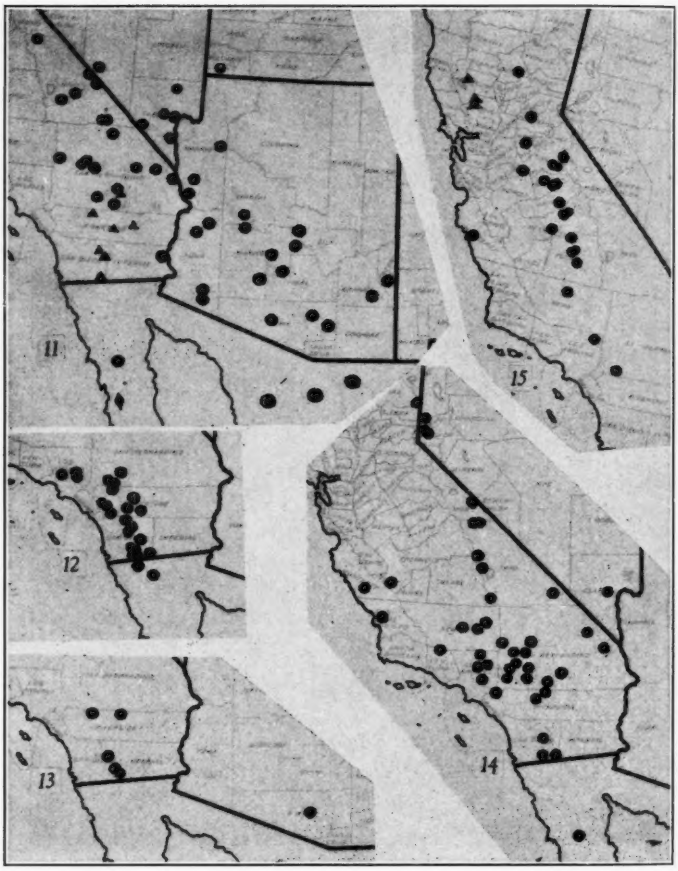

PLATE 3

FIGURES

11. (Triangles)—Distribution of *Nemacladus glanduliferus*.
(Circles)—Distribution of *Nemacladus glanduliferus* var. *orientalis*.
(Diamond)—Distribution of *Nemacladus glanduliferus* var. *australis*.
12. Distribution of *Nemacladus longiflorus*.
13. Distribution of *Nemacladus longiflorus* var. *breviflorus*.
14. Distribution of *Nemacladus gracilis*.
15. (Circles)—Distribution of *Nemacladus rubescens* var. *interior*.
(Triangles)—Distribution of *Nemacladus montanus*.

A Revision of the Genus Brodiaea

Robert F. Hoover

In a previous article (Hoover, 1939) the writer has discussed the reasons for applying the generic name *Brodiaea* only to that group of species which has been treated as the genus *Hookera* by Greene (1886) and by Abrams (1923) and as the subgenus *Hookera* by Jepson (1922). The genus *Brodiaea* as thus defined has been the subject of intensive study, which began some years ago in the form of field observations in the San Joaquin Valley of California. Observation of several species in the living condition indicated that there is much inaccuracy in the published accounts of the genus, resulting largely from the restricted opportunities of authors to study fresh flowers. Consequently there was presented an excellent opportunity for a field student to formulate a classification based on living plants.

During the years from 1937 to 1939, every species of true *Brodiaea*, with the exception of the two restricted to Southern California, was studied by the writer in both field and garden. Mr. Frank F. Gander of the Natural History Museum of San Diego kindly sent fresh flowers of the two Southern California endemics, *B. filifolia* and *B. Orcuttii*. In this manner every species of the genus has been studied and described from fresh material. The difficulty of dealing with dried specimens of these plants does not appear to have been generally appreciated. In the living condition each species is easily recognized, but in drying such important features as the direction assumed by the perianth-segments, the position of the staminodia, and the shape of the filaments are often completely obliterated. When all parts of the plant are present, it is usually possible to refer dried specimens to the various species with reasonable certainty, but even then certain species are difficult to distinguish. Extensive field studies indicate that this difficulty is due almost entirely to distortion of the flowers in pressing rather than to intergradation or hybridization among the entities here given specific rank.

The genus *Brodiaea* is nearly confined to the Pacific Coast region of the United States. Its center of distribution is in north central California, where seven of the ten species here recognized occur, five being restricted to that region. Two Californian species occur also in Oregon, of which one extends northward through Washington to Vancouver Island, British Columbia. Although four species are found in San Diego County at the southern extremity of California, none is known to extend into Mexico, but it is likely that *B. jolonensis* and *B. Orcuttii* will be found within the northern border of Baja California. That *Brodiaea* is a natural genus is indicated by its coherent distribution as well as by the similarity of the species. The genus is confined to the region west of the summits of the Sierra Nevada and the Cascade Range, except near the Columbia, Klamath, and

Pit Rivers, which cut through the Cascade Range at low altitudes. It is represented on both slopes of the high ranges of southern California but does not extend into the deserts. All of the species flower in late spring and early summer. After anthesis the entire vegetative plant, with the exception of the corm, dies.

The flowers of the various species are similar in certain structural details but quite diverse in others. Certain of these details, particularly those of the stamens and staminodia, are constant in groups of individuals having a distinctive general aspect and consequently can be regarded as specific characters. Features of the perianth in anthesis are often of value in differentiating species, while in fruit the nature of the perianth in some species furnishes a reliable means of recognition and, indeed, is thought to constitute the most readily observed indication of true relationship among the species. All species of *Brodiaea* are alike in having the anthers closely approximate around the style, and likewise in the appearance of the adnate portion of the filaments as prominent angular ridges. Except perhaps for slight differences in size, the seeds of all species are nearly identical. There are notable differences in the shape of the capsule, which in *B. appendiculata* is nearly globose and in *B. stellaris* becomes elongated to a remarkable degree. The capsule often tapers somewhat toward the base but in only one species, *B. stellaris*, is it definitely stipitate.

The color of the flowers in *Brodiaea* varies from deep violet to lavender. Some species have generally more deeply colored flowers than others, but color is to some extent variable in all. Occasionally *B. elegans* and *B. californica* may have pink flowers. Albino flowers have been observed by the writer in *B. coronaria* var. *macropoda* and *B. stellaris* and probably occur in all species. The normal color in *B. pallida* is pale lilac or nearly white.

In vegetative features, there are few differences of any significance between the various species. Habit, that is, relative length of scape and pedicels, has been much used to characterize certain species, but is so variable among plants having identical flowers and often even in one colony that no reliance can be placed upon it. The corms of *Brodiaea appendiculata* are remarkable for their thick sheathing coats, but no such distinctive mark is found in the corms of the other species. The leaves of all species of *Brodiaea* are alike in form and do not vary sufficiently in size to furnish any differentiating character. It should be stated that under conditions of nature each species has a distinctive aspect by which it can be immediately recognized. However, when formal statement of differences between species is desired, one must usually resort to conventional characters of flower and fruit.

A treatment of the genus would not be complete without some reference to cytological findings. Such evidence has not been used in formulating the classification here presented because the published results are too incomplete and because such results as have been obtained do not offer conclusive information concerning the relationship of species which are considered to be, on other grounds, closely related. Four species of *Brodiaea* have been examined cytologically by D. A. Johansen (1932). The diploid chromosome number in *B.*

californica was determined as ten, in *B. stellaris* twelve, in *B. minor* fourteen, and in *B. coronaria* forty-two. The last is probably the species here called *B. elegans* and perhaps is a hexaploid derivative of a more primitive form.

While the genus as a whole has a characteristic aspect, field observation soon leads to the recognition of certain subgeneric groups which appear to have closer natural relationships within themselves than to one another. These groups or sections are much more readily recognized when fresh plants are available. In order to emphasize natural relationships as shown by living plants, the sections will be discussed separately. The reasons for regarding certain species as closely related and thus for placing them in the same section are indicated in the discussion under each species. Since all the species are quite similar in some respects and since there seem to be certain affinities between each species of the genus and every other, the sections are not sharply separated by any simple differentiating mark. For that reason an artificial key, in which those features which are not obscured in pressing are used as far as possible, is given as an aid in determining specimens.

Three of the species, *B. appendiculata, B. filifolia,* and *B. Orcuttii,* appear to have no means of vegetative reproduction. In the remaining species, at least occasionally, bulblets are formed either directly around the base of the corm or less commonly at the ends of fragile filiform offsets. As both sorts of vegetative shoots just mentioned always seem to occur in the same species, the term "offset" is for convenience here used to apply to both kinds. Every species which normally bears such offsets probably may lack them in certain localities or in occasional individuals.

Various species of *Brodiaea* have been cultivated for many years, particularly in England. *B. elegans* is in general the most satisfactory for the garden, as it combines large flowers with ease of culture. *B. californica,* which has still larger flowers, does not thrive so readily under garden conditions. All species of *Brodiaea* are ornamental and might advantageously be used more frequently in their native country by flower growers. The smaller forms of *B. coronaria* and *B. minor* are particularly effective in rock gardens.

The writer is grateful to his botanical friends for their cooperation in this study. Among many others, particular acknowledgement is due to Dr. W. L. Jepson for advice and notes on critical forms, to Dr. Lincoln Constance for arranging the loan of specimens from several herbaria, and to Mr. F. F. Gander for sending fresh flowers of the species occurring in San Diego County. Acknowledgement is made of the consideration shown by those in charge of the following herbaria where specimens were studied or from which material was borrowed: California Academy of Science (CA), R. F. Hoover (at present in possession of the writer) (H), W. L. Jepson (J), Oregon State College (OS), Stanford University, Dudley Herbarium (S), Natural History Museum of San Diego (SD), University of California (UC), University of Oregon (UO), University of Washington (UW), Willamette University (W), Washington State College (WS), California Forest and Range Experiment Station, Vegetation Type Map Herbarium (VT). Additional specimens were examined from the University of Colorado Herbarium and from the herbarium of J. William Thompson, but none of these are cited here. Citation of most of the commoner species and varieties is restricted to a sufficient number of well preserved specimens to give an accurate indication of geographical distribution.

BRODIAEA Smith, Trans. Linn. Soc. 10:2. 1811. Intern. Rules Bot. Nomen. 75. 1906 (conserved over *Hookera*); ed. 3, 144. 1935 (*B. grandiflora* Smith chosen as type species).

Hookera Salisb., Parad. Lond. pl. 98. 1808. Greene, Bull. Cal. Acad. **2**:136. 1886. *Brodiaea* subgenus *Hookera* Eastwood, Bergen's Elements of Botany, Pacific Coast Edition, Key and Flora 20. 1897.

Perennial herbs with narrow basal leaves and one or few scapes from a corm. Corm subglobose, with dark brown fibrous coat. Leaves elongate, rounded on lower side, flat or concave on upper side. Scape slender (about 1 to 2 mm. in diameter), rigid, terete. Flowers in solitary umbels subtended by small scarious acuminate bracts. Pedicels jointed at base and apex, the flowers readily deciduous on drying. Perianth with well defined tube and six segments, the three outer segments commonly narrower than the inner. Stamens three, alternating with as many staminodia, or in one species the staminodia absent. Fertile stamens erect, closely appressed to the style. Filaments continued below attachment to perianth as prominent longitudinal internal ridges on perianth-tube. Anthers attached dorsally near the sagittate base. Style stout, continuous with ovary. Stigma three-parted, with long spreading and recurving lobes. Fruit a loculicidal capsule, the seeds few or several in two rows in each cavity. Seeds black, obtusely angled, longitudinally striate.

ARTIFICIAL KEY TO THE SPECIES

Staminodia present.
- Stamen-appendages absent (or rudimentary in *B. californica*).
  - Perianth-tube becoming firm-membranous or cartilaginous; staminodia obtuse or acute.
    - Perianth-segments 1 to 2 times as long as tube; perianth-tube not splitting in fruit.
      - Perianth-tube not or slightly constricted above ovary; staminodia straight or curved only at apex.
        - Earliest flowers of umbel with longest pedicels; staminodia narrower than perianth-segments; filaments angular or flattened (dorsally channeled in *B. jolonensis*).
          - Filaments 2 to 6 mm. long, slender or only the lower part dilated.
            - Perianth-tube funnelform at anthesis; staminodia plane, standing apart from stamens, acute, usually shorter than stamens. ..... 1. *B. elegans*
            - Perianth-tube ovoid to narrowly campanulate; staminodia involute, usually obtuse, longer than stamens. ..... 2. *B. coronaria*
          - Filaments 1 mm. long, broadly triangular. ..... 3. *B. jolonensis*
        - Earliest flowers of umbel with shortest pedicels; staminodia as wide as perianth-segments; filaments with reflexed margins. ..... 5. *B. pallida*
      - Perianth-tube strongly constricted above ovary, the segments rotate; staminodia arcuately curved outward ..... 4. *B. minor*
    - Perianth-segments 3 times as long as tube; perianth-tube splitting in mature fruit. ..... 7. *B. californica*
  - Perianth-tube becoming thin-membranous and fragile, transparent; staminodia acuminate, curved outward at base and apex. ..... 9. *B. filifolia*
- Stamens each with two appendages on back.
  - Perianth-tube not splitting; staminodia broad, entire on margin; capsule elongate; corm-coats thin, not sheathing. ..... 6. *B. stellaris.*

Perianth-tube splitting longitudinally in mature fruit; staminodia narrow, undulate-denticulate; capsule subglobose; corms with thick sheathing coats. ..... 8. *B. appendiculata*

Staminodia absent. ..... 10. *B. Orcutti*

Section 1. CORONARIAE. Flowers of varying size; perianth-tube attenuate or rounded at base, of tough texture, not splitting in fruit; perianth-segments more or less recurved; staminodia involute or plane but never undulate, either obtuse or acute; filaments angular, flattened, or dorsally channeled; anthers with entire or shortly bifid apex, the basal lobes short.

On morphological grounds this section is regarded as most primitive, and it is spread over a far wider extent of territory than the remaining groups, living under very diverse conditions of geology and ecology. Regardless of these indications of relative antiquity, the group is extremely plastic, showing several forms differing widely in aspect but connected by intermediates. In the classification here presented, structural details of the flower are regarded as most important, while differences in habit and minor vegetative features are considered as indicating no more than varietal distinction.

Staminodia not incurved at apex; filaments narrow or only the lower part dilated, narrower than anthers, 2 to 6 mm. long, angled or flattened.

Perianth-tube funnelform at anthesis; staminodia plane, distant from stamens, acute, usually shorter than stamens. ..... 1. *B. elegans*

Perianth-tube ovoid to narrowly campanulate; staminodia involute, usually directed inward toward stamens or folded around them, usually obtuse, longer than stamens. ..... 2. *B. coronaria*

Staminodia spreading, but incurved at apex; filaments broadly triangular, as wide as anthers, 1 mm. long, dorsally channeled. ..... 3. *B. jolonensis*

1. **Brodiaea elegans** sp. nov.

Hookera coronaria Salisb., sense of Greene, Bull. Cal. Acad. **2**:136. 1886; sense of Abrams, Ill. Fl. Pac. St. **1**:405. 1923, as to description and figure. *B. coronaria* (Salisb.) Jepson, Fl. Cal. **1**:287. 1922, as to description, figure, and most specimens cited.

Perianthii tubo infundibuliforme, segmentis ascendentibus, apice recurvatis; staminodiis planis, a staminibus distantibus, acutis vel apice paulo trifidis, 9 ad 11 mm. longis; staminibus plerumque staminodia superantibus; filamentis angularibus, 4 ad 6 mm. longis; antheris 7 ad 10 mm. longis, apice integris vel breviter bifidis; capsulo ovoideo.

Type: 3 miles north of Nevada City, Nevada County, California, *Constance 2289* (UC).

Corm nearly always with offsets; scape rather stout, 1 to 4 dm. tall; pedicels ascending, 0.5 to 8 cm. long; perianth violet, rarely pink, the tube funnelform, gradually enlarged upward from the acute base, 9 to 17 mm. long, the segments acute, 17 to 26 mm. long, ascending at base, strongly recurved; staminodia flat, distant from stamens, acute or slightly three-toothed at apex, rarely obtuse, 9 to 11 mm. long; stamens usually exceeding staminodia; fila-

ments angular, slightly dilated at base, 4 to 6 mm. long; anthers 7 to 10 mm. long, entire or with short narrow notch at apex; capsule ovoid.

Hood River County, Oregon, to San Bernardino County, California.

OREGON: Hood River Co.: Hood River, 1882, *Henderson* (S). Clackamas Co.: near Canby, *Morrill 149* (UW). Marion Co.: Salem, *J. C. Nelson 240* (S). Benton Co.: Corvallis, *Gilbert 482* (OS). Lane Co.: Eugene, 1914, *Sanborn* (UO). Douglas Co.: Drain Hill, *Kimber 4* (S); Roseburg, *Thompson 4407* (S), 1935, *Kincaid* (UW). Jackson Co.: near Trail, *J. T. Howell 6814* (CA); Sams Valley, *Henderson 12779* (UO). Josephine Co.: Grant's Pass, *Peck 1349* (W), 1909, *J. Howell* (UO); Waldo, *Applegate 7313* (S). Curry Co.: Pistol Mountain north of Brookings, *Applegate 4738* (S). CALIFORNIA: Del Norte Co.: near Gasquet, *Eastwood and Howell 3763* (CA); Smith River below Patrick's Creek, *Applegate 4718* (S). Siskiyou Co.: meadow near Yreka, *Butler 1421* (UC); Highland Mine, *Butler 888* (UC). Shasta Co.: Montgomery Creek, *Eastwood 663* (CA); Cottonwood, *L. E. Smith 325* (CA). Humboldt Co.: Klamath River, *Chandler 1413* (UC); Horse Mountain Pass, *Tracy 7695* (UC). Trinity Co.: East Fork of Hayfork Creek, *Clar 88* (VT). Tehama Co.: Payne Creek, *Jepson 12341* (J). Mendocino Co.: Potter Valley, *Eastwood 12738* (CA). Butte Co.: Berry Canyon, *Heller and Brown 5492* (S); 8 miles north of Oroville, *Heller 11385* (CA, OS, S, UC.) Yuba Co.: Los Vergils, *Eastwood 10583* (CA). Nevada Co.: near Grass Valley, *Heller 8098* (S, UC); near Kress, *Hall 10205* (UC). Colusa Co.: near College City, *Stinchfield 300* (UO, UW). Lake Co.: Indian Valley, *Hoover 3577* (H); Binkley Ranch, *Jussel 220* (CA). Placer Co.: Lake Theodore, *Hall 10217* (UC); Loomis, 1914, *Rixford* (CA). Sonoma Co.: 2 miles southeast of Healdsburg, *Hoover 3606* (H); Sonoma Creek Canyon, 1904, *M. S. Baker* (UC). Napa Co.: Calistoga, *Eastwood 4648* (CA), *4633* (CA); Howell Mountain, *Bacigalupi 1864* (S). Solano Co.: Gates Canyon, *Lewis 92* (VT); Benicia, *Eastwood 10485* (CA). Sacramento Co.: Sacramento, *Hoover 1131* (H). Eldorado Co.: Plum Creek, *Johannsen and Gifford 345* (VT); Randolph Canyon, *Belshaw 2335* (VT). Amador Co.: Ione, *Braunton 1009* (UC); Agricultural Station, *Hansen 40* (S). Marin Co.: Rodeo Lagoon, 1921, *Eastwood* (CA). Contra Costa Co.: Donner Canyon, *Jepson 7599* (J). Calaveras Co.: Salt Springs Valley Reservoir, *Hoover 2438* (H); Copperopolis, *Tracy 5676* (UC), *Davy 1372* (UC). San Joaquin Co.: Clements, *Jepson 1822* (J). Tuolumne Co.: Bear Creek, *Williamson 192* (CA, S); Pate Valley, 1919, *Clemens* (CA). San Francisco Co.: Presidio, *Eastwood 272* (CA). San Mateo Co.: back of Redwood City, *Hichborn 280* (S); between Slate and Oil Creeks, *Carlson 72* (VT). Alameda Co.: Berkeley, *Michener and Bioletti 2066* (UC); Niles, 1897, *Jepson* (UC). Stanislaus Co.: 10 miles south of Modesto, *Hoover 573* (H); Adobe Valley, *Elmer 4333* (CA, S, UC, UO), *5071* (CA, OS, UC, UO). Santa Clara Co.: Grand View, *Pendleton 855* (UC); foothills west of Los Gatos, *Heller 7442* (OS, UC). Mariposa Co.: Merced Lake trail, *Schreiber 2067* (UC). Merced Co.: 10 miles west of Merced, *Hoover 1118* (H). Santa Cruz Co.: near Eccles, 1897, *Dudley* (S). Madera Co.: Raymond, *Eastwood 12603* (CA); Madera, *Eastwood 12435* (CA). San Benito Co.: 2¼ miles north of San Juan Bautista, *Belshaw 2190* (VT); Eagle Creek, 1899, *Dudley* (S). Monterey Co.: 1¼ miles north of Sugarloaf Peak, *Belshaw 2177* (VT). Fresno Co.: Pine Ridge, *Hall and Chandler 199* (UC); Orange Cove, *Hoover 1008* (H). Tulare Co.: 1 mile below Lonepine Meadow, *Bacigalupi 1795* (S); near Mineral King, *Coville and Funston 1464* (S). San Bernardino Co.: Little Bear Valley, *Parish 1660* (S); Little Green Valley, *G. R. Hall 22* (UC); Strawberry Peak, *Abrams 1994* (S), *Abrams and McGregor 724* (S); San Bernardino Valley, *Wright 1814* (UC).

Brodiaea elegans is the species which has been known in California as *B. grandiflora* or *B. coronaria*. The reasons for applying those names to a different plant are discussed under the description of the next species. *B. elegans* is the plant represented by the excellent figure published by Jepson (1922) and

designated as *B. coronaria,* and by that designated as *Hookera coronaria* by Abrams (1923). Apparently it is also the plant figured by Baker (1896) as *B. californica.*

Brodiaea elegans evidently has been regarded as distinct from the species here treated as *B. coronaria* by nearly all botanists who have known both in the field. Specimens of this group from central and northern California and from southwestern Oregon can be readily distinguished as two variable but mutually exclusive species. Occasional plants may lose some of their distinctive features in drying, but no such difficulty has been encountered with fresh plants. However, certain specimens from near the northern and southern limits of distribution of *B. elegans,* where the writer has had no opportunity for field observations, are very perplexing and may be truly intermediate between the two species. In San Bernardino County, California, the plants have flowers which in size and shape are typical of those of *B. elegans* but with staminodia longer than the stamens. The problem is complicated by the fact that, except for this localized occurrence, *B. elegans* has not been collected south of San Benito and Tulare Counties. However, in the Sierra Nevada of Tulare County, plants which are certainly *B. elegans* also frequently have staminodia longer than the stamens. Although none of the specimens from San Bernardino County shows clearly whether the staminodia were involute or plane, this form is here included in *B. elegans* on the basis of the facts stated above. In northwestern Oregon, particularly in Clackamas County, is found another uncertain form which appears more like *B. coronaria* in the shape of the flower but in size characters falls within the range of variation of *B. elegans.* As nearly as can be determined from the dried specimens, most of these large-flowered plants have flat staminodia distant from the stamens. On the basis of his observations of the California plants, the writer considers that to be a reliable character for distinguishing *B. elegans* from *B. coronaria.* Consequently this northern form is also here included in *B. elegans.* No information regarding the appearance of fresh flowers of this plant could be obtained from botanists who have collected in Oregon.

Brodiaea elegans is very common in the interior of central and northern California, where it is known as "Harvest Brodiaea," and extends from near sea level to altitudes of at least 7,000 feet. It grows on treeless or openly wooded hills and plains, or in open meadows in the mountains. It is absent from the driest parts of the southern San Joaquin Valley and of the inner South Coast Ranges of California, where the annual precipitation averages less than ten inches. The flowering season of *Brodiaea elegans* depends on local climate and in the San Joaquin Valley often begins as early as April. In the Sierra Nevada and the outer Coast Ranges and in Oregon flowering takes place from May to July, while in the fog-belt along the immediate coast flowers have been seen as late as September.

1a. **Brodiaea elegans** Hoover var. **mundula** (Jepson) comb. nov.

B. coronaria (Salisb.) Jepson var. *mundula* Jepson, Fl. Cal. **1**:287. 1922.

Corms without offsets; scapes averaging taller; flowers on short pedicels,

the umbels compact; perianth-segments deep violet; all parts of the flower smaller: staminodia 7 to 8 mm. long; filaments 3 mm. long; anthers 6 to 7 mm. long.

Tuolumne County, California, at about 2500 feet altitude.

CALIFORNIA: Tuolumne Co.: Duffield Canyon, *Jepson 7683* (J, type); Tuolumne City, *Hoover 2551* (H); 3 miles east of Sonora, *Hoover 3617* (UC).

A form of the species with short pedicels is of frequent occurrence, but in its most marked form this variety is very local. While typical *B. elegans* always produces offsets except under extremely unfavorable environmental conditions, the variety *mundula* never has them. The typical form of the species grows with the variety, but intermediate individuals are fewer than would be expected.

2. *Brodiaea coronaria* (Salisb.) Engler, Notizbl. Königl. Bot. Gart. 2:317. 1899; Jepson, Madroño 1:61. 1917.

Hookera coronaria Salisb., Parad. Lond. pl. 98. 1808. *B. grandiflora* Smith, Trans. Linn. Soc. **10**:2. 1811. *B. synandra* Jepson, Fl. Cal. **1**:288. 1922, as to most specimens cited; not *Hookera synandra* Heller. (?) *B. synandra* Jepson var. *insignis* Jepson, Fl. Cal. **1**:288. 1922. *B. Howellii* Eastw., Leafl. West. Bot. **2**:111. 1938 (not Wats.).

Corm either with or without offsets; scape 5 to 25 cm. tall; pedicels ascending, 1 to 10 cm. long; perianth violet to lilac, the tube rounded at base, 7 to 12 mm. long, the segments spreading, 13 to 22 mm. long; staminodia with involute margins, usually leaning in toward the center of the flower and often folded around the stamens, sometimes slightly spreading at apex, rarely erect, often constricted at base, at apex rounded, retuse, or obtusely three-toothed, sometimes apiculate, 6 to 11 mm. long, exceeding the stamens; filaments 2 to 4 mm. long, more or less flattened or wing-margined, dilated at base; anthers 4 to 7 mm. long, broadly emarginate to subentire at apex; capsule ovoid.

Southern part of Vancouver Island, British Columbia, to San Diego County, California.

BRITISH COLUMBIA: Hydra Hill, Discovery Bay, Nanaimo, 1920, *Eastwood* (CA); Oak Bay, 1919, *Anderson* (WS); Thetis Lake, 1904, *Anderson* (WS); West Victoria, *Law* (UC); Victoria, 1899, *Pineo* (UC); Oak Park, Victoria, *Eastwood 9711* (CA). WASHINGTON: San Juan Co.: Stuart Island, *Lawrence 27* (WS); bluffs north of Friday Harbor, *Peck 12601* (WS); Wasp Island, 1904, *Pope* (UW); Brown's Island, *Zeller 928* (CA). Skagit Co.: Sinclair Island, 1922, *Sprague* (WS); Mt. Erie, Fidalgo Island, *Flett 2104* (WS). Island Co.: Goose Rock, Whidby Island, *H. W. Smith 1330* (UW); Camano Island, 1894, *Gardner* (UC). Clallam Co.: Elwha River, *G. N. Jones 3526* (UW). Kitsap Co.: Waterman, *Warren 76* (WS). King Co.: Ballard, 1904, *Frye* (UW); Alki Point, *Piper 295* (UW). Pierce Co.: Tacoma, *Flett 906* (WS); Lake Park, *Piper 2093* (UO, WS). Grays Harbor Co.: near McCleary, *Thompson 7350* (S); near Satstop, *Heller 4031* (UC, WS). Thurston Co.: Gate City, 1892, *Henderson* (UW, WS). Clarke Co.: Fourth Plain, 1899, *Piper* (WS). OREGON: Columbia Co.: St. Helens, 1877, *T. Howell* (UO). Hood River, 1880, *Henderson* (UO). Wasco Co.: The Dalles, *Thompson 2819a* (S). Clackamas Co.: Willamette Falls, *Sheldon 9744* (UO). Polk Co.: Grande Ronde, *Eastwood and Howell 3573* (CA). Marion Co.: Salem, *Johnson* (UW). Lincoln Co.: 4 miles south of Depoe Bay, *Peck 13468* (W); Yaquina Head, *Peck 13482* (W varies toward var. *macropoda*). Lane Co.: Eugene, 1925, *Constance* (UC); Jasper

Cliffs, *Henderson 18712* (UO). Jackson Co.: Fall Creek, *Copeland (C. F. Baker 3484)* (S, UC); Pinehurst, *Applegate 4392* (S, UC). Klamath Co.: Aspen Lake, *Applegate 3398* (S), *3408* (S); Keno, *Constance (Henderson 9659)* (UO, WS). CALIFORNIA: Siskiyou Co.: Sisson, *Eastwood 1157* (CA). Modoc Co.: Duncan Horse Camp, *J. T. Howell 12272* (CA, S); northwest of Canby, *Peirson 6910* (UC). Lassen Co.: Dixey Mountains, 1894, *Baker and Nutting* (UC). Shasta Co.: between Castella and Sims, *Heller 12441* (CA, OS, S); Cottonwood, *Hoover 1185* (H). Trinity Co.: Trinity Alps Resort, *Eastwood and Howell 4905* (CA, type of *B. Howellii* Eastw.). Tehama Co.: Henleyville, 1938, *S. A. Long* (J). Plumas Co.: Prattville, *Heller and Kennedy 8796* (CA, S). Butte Co.: 10 miles northwest of Chico, *Hoover 2246* (H); Clear Creek, *Heller 11382* (CA, OS, S, UC). Sutter Co.: Pleasant Grove, *Hoover 1145* (H); Riego, *Hoover 1139* (H). Placer Co.: 2 miles southeast of Sheridan, *Hoover 4095* (S). Sacramento Co.: Elverta, *Hoover 1135* (H); Fair Oaks, *Ramaley 11257* (UC). Solano Co.: Suisun, *Eastwood 10401* (CA). Calaveras Co.: Salt Springs Valley, *Tracy 5662* (UC); near Milton, *Davy 1346* (UC). Tuolumne Co.: Chinese Camp, *Hoover 2374* (H). Sonoma Co.: 2 miles north of Windsor, *Eastwood and Howell 2517* (CA, approaches var. *macropoda*). Contra Costa Co.: 1½ miles east of Mulligan Hill, *Belshaw 2079* (VT). San Mateo Co.: Hillsborough, 1925, *U. S. Grant* (SD). Santa Cruz Co.: Watsonville Junction, *Belshaw 2136A* (VT). San Benito Co.: near Hollister, *J. T. Howell 13804* (CA), *Hoover 3486* (H); Pinnacles, 1921, *Sutliffe* (CA). San Luis Obispo Co.: 2¾ miles northwest of Eldorado School, *Hendrix 246* (VT). Tulare Co.: Shepherd Cove, *Fry 397* (J, type of *B. synandra* var. *insignis* Jepson[1]). Kern Co.: Glenville, *Weston 155* (CA). Los Angeles Co.: Elizabeth Lake, *Parish 1931* (UC). Orange Co.: "Santa Ana Mts.," 1908, *King* (J). Riverside Co.: Strawberry Valley, *Hall 2093* (S, UC). San Diego Co.: Rainbow Valley, *Gander 5784* (SD); Julian, 1894, *T. Brandegee* (UC); near Cuyamaca Lake, 1932, *Epling, Darsie, Knox, and Robison* (CA, S, UC, UO); East San Diego, 1922, *Woodcock* (SD).

Brodiaea coronaria, like *B. elegans*, grows in a wide variety of situations, but as shown by its occurrence in California it is evidently less tolerant of arid conditions than *B. elegans*. There are some notable discontinuities in the range of typical *B. coronaria*. In southern Washington it is not known to occur between the Chehalis River valley and the immediate vicinity of the Columbia River. In California it is common throughout the Sacramento Valley but has never been found in the San Joaquin Valley and is quite rare in the Sierra Nevada foothills. It is apparently absent from the coast of southern Oregon and northern California, and near the coast in central California it is replaced mainly, though not entirely, by var. *macropoda* and by intergrades to that variety.

The name *Brodiaea coronaria* is here used for the species which, prior to 1879, was universally known as *B. grandiflora*. Because *Hookera coronaria* was cited without comment in synonymy under the original description of *B. grandiflora*, the two names are necessarily synonymous. The identity of *B. grandiflora*, as understood by earlier authors, is easily determined from the figures in the "Botanical Register" (pl. 1183), the "Botanical Magazine" (pl. 2877), Paxton's "Magazine of Botany" (12:221), and Meehan's "Flowers and Ferns of the United States" (2: pl. 20). All of these figures clearly show

[1] A peculiar form very doubtfully referred here and in great need of further study. The staminodia are apparently as broad as in *B. pallida* and the filaments as short as in *B. jolonensis*. Being known only from one collection, it may be an abnormal seasonal variation.

a flower with ovoid perianth-tube and involute staminodia approximate around the stamens, and so represent the plant here discussed as *B. coronaria*.

The prevailing confusion of this species with *B. elegans* may be traced to Watson (1879). The staminodia of *B. grandiflora* were described by Watson as "entire, about equalling the linear anthers," and on that basis the name *B. grandiflora* might be readily applied to the plant here called *B. elegans*, as there was no other name available for it. However, Watson included British Columbia in the range of *B. grandiflora*. In British Columbia, as well as in Washington, *B. elegans* does not occur. Thus it came about, apparently as a result of Watson's treatment, that in Washington and British Columbia the name *B. grandiflora* was continued in its previous sense after 1879, while in California it was gradually restricted to the other species, *B. elegans*. The Californian representation of *B. coronaria* then came to be generally included under the name *B. minor*, a name belonging properly to a quite different species, and more recently has been called *B. synandra*, a name actually based on a form of *B. californica*. When the name *Brodiaea grandiflora* was replaced by *B. coronaria* in accordance with the rule of priority, the two entities coeinued to be confused under the name *B. coronaria*.

The original description of *Hookera coronaria* is not sufficiently detailed to be decisive, but in the accompanying figure the staminodia are clearly represented as longer than the stamens, and the shape of the perianth is the same as in the species here treated as *B. coronaria*. The perianth-tube is shown as somewhat rounded at the base and slightly constricted below the segments, whereas *B. elegans* has a strictly funnelform perianth-tube. It should be noted that the name *B. coronaria* is not appropriate for *B. elegans*, for in that species the staminodia stand apart from the stamens and thus do not form a "corona." Because *Hookera coronaria* was described from cultivated plants of unknown wild origin, it is not possible to determine its identity by reference to the type locality. All the available evidence, however, as summarized above, favors the application of the name *B. coronaria* to the present species, the most widely distributed of the genus, and accordingly *B. elegans* has been described on a previous page as a new species.

As here defined, *B. coronaria* includes a number of rather marked variants which do not differ sufficiently in flower structure to be regarded as distinct species. In the lower Sacramento Valley in 1936 the writer observed two forms of this species which were quite distinct but which in flower structure seemed identical. One, in which the corms lacked offsets and the perianth was lavender, grew in hard-packed dry soil. The other, in which the corms produced numerous offsets and the perianth was deep violet, grew in low places where the soil remained moist until the flowering season. These two kinds of plants often grew in close proximity to each other and perhaps should be considered as oecotypes. The varieties discussed below have more geographical significance.

2a. **Brodiaea coronaria** (Salisb.) Engler var. **rosea** (Greene) comb. nov. *Hookera rosea* Greene, Bull. Cal. Acad. **2**:137. 1886. *B. rosea* Baker, Gard. Chron. ser. 3, **20**:214. 1896.

Corm without offsets; perianth pale lavender (drying pinkish); staminodia folded around the stamens, abruptly constricted at base, nearly plane below but becoming strongly involute toward apex (thus appearing narrowly triangular as viewed from the back); filaments triangular or abruptly dilated toward base.

Local in the hills around Indian Valley in Lake County, California.

CALIFORNIA: Lake Co.: between Hough's Springs and Colusa Co. line, *Heller 12381* (CA, OS, S); Indian Valley, *Hoover 3572* (UC), *Jepson 8985* (J), *18948* (J).

Hookera rosea Greene was based on a collection made by Curran near Hough's Springs. Practically any of its characteristics can be duplicated in specimens of typical *B. coronaria*. It is here maintained as a variety on the basis of a certain combination of characters together with geographical isolation. Perhaps the most notable feature as seen in fresh flowers is the apparent narrowing of the staminodia upward. However, if the staminodia are unrolled, they are seen to be emarginate and as broad at the apex as near the base. The broadening of the base of the filaments is only slightly more marked than in the typical form of the species. The fresh flowers are not rose-red as originally described, although the mid-veins of the perianth-segments are somewhat rose-purple in color. In habit this variety is rather variable but is usually similar to typical *B. coronaria*.

2b. **Brodiaea coronaria** (Salisb.) Engler var. **kernensis** var. nov.

Scapo 3 ad 7 (ad 25) cm. alto, pedicellis aequilongo; staminodiis erectis, a staminibus distantibus.

Type: Poso Creek oil field, Kern County, California, *Hoover 4083* (UC).

Scape 3 to 7 cm. (among tall vegetation as much as 25 cm.) tall, about equalling the pedicels except in tall plants; staminodia erect, not directed toward stamens.

Kern County, California, on the eastern margin of the San Joaquin Valley and in valleys of the adjacent mountains.

CALIFORNIA: Kern Co.: Poso Creek oil field, *Hoover 4083* (UC, type, S); 1½ miles northeast of Kernville, *Voegelin 195* (UC); near Oil City, *Heller 7637* (S, UC); near Edison, *Eastwood and Howell 4008* (CA); 10 miles southeast of Bakersfield, *Munz 10114* (UC); 4 miles northwest of Tejon Ranch, *Keck and Clausen 3168* (S); Tehachapi, *Eastwood 3250* (CA).

The erect staminodia which characterize this variety are not evident in herbarium specimens. Perhaps all southern California plants of *B. coronaria* would be referable to var. *kernensis* on the basis of that character if fresh flowers from all localities were available. Apparently the normal form of var. *kernensis* is represented by plants with rather short scapes about equalling the pedicels. The taller plants, as observed at the type locality of this variety, grow only among tall weeds. Var. *kernensis* is thus about intermediate between typical *B. coronaria* and var. *macropoda*. Because it can not as a whole

be definitely referred to either and is somewhat isolated geographically, it seems best considered as a separate category. In most specimens the staminodia are deep violet even to the apex. It should be noted that one collection from Kern County *(Weston 155)* is apparently quite typical *B. coronaria* and is cited as such above.

2c. **Brodiaea coronaria** (Salisb.) Engler var. **macropoda** (Torr.) comb. nov.

B. grandiflora Smith var. *macropoda* Torr., Pac. R. Rep. **4**:149. 1857. *Hookera macropoda* Ktze., Rev. Gen. **2**:712. 1891. *B. terrestria* Kell., Proc. Cal. Acad. **2**:6. 1859 (corrected by Watson and subsequent authors to *terrestris*). *Hookera terrestris* Britten, Journ. Bot. **24**:51. 1886. *B. Torreyi* Wood, Proc. Philad. Acad. **20**:172. 1868.

Scape wholly subterranean, or extending as much as 5 cm. above the ground, the portion above ground considerably shorter than the longest pedicels, which are slender and 3 to 20 cm. long (or in depauperate plants the pedicels as short as 1 cm.); flowers averaging smaller; staminodia not closely folded around stamens.

Coos County, Oregon, to San Luis Obispo County, California, mostly on the coast, rarely as far inland as the west side of the Great Valley.

OREGON: Coos Co.: Marshfield, *Haydon* (CA); Coos Bay, *Henderson 13758* (UO); Charleston, 1926, *Scullen* (OS, UC); Cape Arago, 1928, *Henderson* (UO). Curry Co.: The Heads, Port Orford, *Peck 8457* (W). CALIFORNIA: Del Norte Co.: Crescent City, *Parks 8274* (UC). Humboldt Co.: Bucksport, *Tracy 3196* (UC); mouth of Little River, *Wiggins 5877* (S, UC). Mendocino Co.: Comptche, *McMurphy 178* (S); Fort Bragg, *Bolander 4759* (UC). Colusa Co.: between Princeton and Norman, *Eastwood 11170* (CA). Napa Co.: Myrtledale Geyser, *Bacigalupi 1251* (S), *Eastwood and Howell 5517* (CA); Napa Junction, 1888, *Sonne* (UC). Solano Co.: Little Oak, *Jepson 554* (J). Sonoma Co.: between Santa Rosa and Sebastopol, 1905, *K. Brandegee* (UC); Bodega, *Chandler 672* (UC). Marin Co.: Point Reyes, *Davy 6848* (UC), *Eastwood 4746* (CA). Contra Costa Co.: near Byron, *Wiggins 4573* (S, UC); Byron Hot Springs, *Hoover 2122* (H). San Francisco Co.: Mission Hills, 1880, *Rattan* (S); Hunter's Point, 1916, *Eastwood* (CA). San Mateo Co.: Crystal Springs Lake, *C. F. Baker 462* (CA, UC, WS); Big Basin, 1897, *Dudley* (S). Santa Clara Co.: Stanford University, 1900, *Atkinson* (S); Alma, *Elmer 3006* (UO). Santa Cruz Co.: Swanton, 1912, *Rich* (S). Monterey Co.: Pajaro Hills, *Chandler 383* (UC); Salinas road near Del Monte, *Heller 6773* (S, UC); Carmel, *Randall 296* (S). San Benito Co.: ridge between San Benito River and Bitterwater, *Hall 9908* (UC); Hernandez, 1903, *Lathrop* (S). San Luis Obispo Co.: 3 miles east of Templeton, *Wiggins 2076* (S); Santa Margarita, 1933, *Wall* (CA); Osos Valley, 1910, Condit (UC).

This common plant of coastal middle California differs from typical *B. coronaria* and var. *kernensis* in its extremely short scapes and in its usually longer pedicels. So far as has been observed, flower structure is nearly identical in these forms. The flowers of var. *macropoda* are usually smaller than those of typical *B. coronaria*, but the complete range of variation is practically the same in both. Ordinarily the staminodia in this variety lean in toward the center of the flower but do not touch the stamens. However, the ordinary tall plants of *B. coronaria* show much variation in this respect. Watson (1879)

described the staminodia of *"B. terrestris"* as "yellow," and this curious error has been perpetuated by all subsequent authors describing this form. In all plants which the writer has seen, the staminodia are white or tinged with violet, just as in every other species of *Brodiaea*.

Offsets are present in most herbarium specimens of this variety with which corms are included and whenever originally present are produced each year under cultivation. In plants originally obtained in the hills near Stanford University and cultivated for several years, offsets were never produced. This observation indicates that presence or absence of offsets is essentially a genetic character which is constant in certain localities, rather than a response to seasonal conditions.

The plant on which *B. grandiflora* var. *macropoda* was based was collected on Santa Rosa Creek, Sonoma County, by Bigelow. *B. terrestria* was the name applied by Kellogg, without citing any collection which might be regarded as the type, to plants growing in the vicinity of San Francisco. The majority of botanists have accepted Kellogg's name as corrected by Watson. This plant is here given varietal recognition because its distinctive habit is primarily a genetic character, being largely independent of environment. However, plants growing among tall grass tend to produce long scapes and thus simulate typical *B. coronaria*, as illustrated by the collection made between Santa Rosa and Sebastopol, California, by K. Brandegee. Conversely, when typical *B. coronaria* is subject to unfavorable conditions, the scapes may be extremely short, as in *Peck 12601* from Friday Harbor, Washington, although the pedicels also are very short in such cases. Aside from such variations resulting directly from environment, actual intergradation between the variety and typical *B. coronaria* appears to occur on the coast of Oregon and in western middle California.

3. *Brodiaea jolonensis* Eastw., Leafl. West. Bot. 2:111. 1938.

Corm usually without offsets; scape usually rather slender, 1 to 20 cm. tall; pedicels ascending, 2 to 12 cm. long; perianth violet, the tube rounded at base, 8 to 13 mm. long, firm-membranous in fruit, the segments spreading, 10 to 14 mm. long; staminodia violet, involute, 4 to 6 mm. long, obtuse or retuse, longer than the stamens, spreading below but incurved at apex; filaments 1 mm. long, broadly triangular, broader than anthers, channeled on the back, somewhat united with the bases of the staminodia to form a disk; anthers 3 to 5 mm. long, emarginate at apex; capsule ovoid, acuminate at apex.

Near the coast from Monterey County to San Diego County, California.

CALIFORNIA: Monterey Co.: Tassajara Hot Springs, *Elmer 3218* (CA, S); near "the Indians," *Eastwood and Howell 2406* (CA); near Jolon, 1915, *Starr* (CA, type), *Eastwood and Howell 2390* (CA), *Hoover 4075* (UC); plain west of Jolon, 1895, *Dudley* (S); Burro Trail between Jolon and Gorda, 1909, *K. Brandegee* (UC). San Luis Obispo Co.: near San Simeon, *Eastwood and Howell 5980* (CA); Morro, 1911, *Condit* (UC); Morrow Bay, 1935, *Sinsheimer* (CA). Santa Barbara Co.: Ellwood, *Eastwood 194* (CA); Mission Creek, 1908, *Eastwood* (CA); Santa Barbara, 1903, *C. B. Grant* (S); Santa Cruz Island, *T. Brandegee* (S). Los Angeles Co.:

Inglewood, *Abrams 1453a* (S); "Salt works," 1884, *Lyon* (S). San Bernardino Co.: San Bernardino, 1880, *Cleveland* (SD). San Diego Co.: Linda Vista, *Gander 5482* (SD); mesa northeast of Murray Dam, *Gander 1680* (SD); San Diego, *T. Brandegee (C. F. Baker 1652)* (CA, UC), 1891. Dunn (UC), 1885, *Cleveland* (SD, UC, UO); University Heights, 1897, *Snyder* (SD); Proctor Valley, *Gander 5772* (SD); Otay, *Chandler 5112* (S).

This species is evidently related to *B. coronaria* var. *macropoda*, and a few specimens from San Luis Obispo County seem to connect the two. *B. jolonensis* is otherwise quite distinct from all other forms. In Monterey County *B. jolonensis* and *B. coronaria* var. *macropoda* occupy separate areas and are not confluent. In southern California the present species does not mingle with typical *B. coronaria*, which occurs mainly at higher altitudes. In some respects, particularly in the dorsally channeled filaments, *B. jolonensis* seems transitional between the sections Coronariae and Stellares.

Although the species is constant in its remarkable stamen characters, it is quite variable in habit. The various forms are not geographically consistent, however, and therefore can not conveniently be given the taxonomic recognition accorded to the corresponding forms of *B. coronaria*. The southern form of *B. jolonensis* often simulates *B. coronaria* var. *macropoda* in habit and is the basis for all records of "*Brodiaea terrestris*" in southern California. However, some specimens from Los Angeles and San Diego Counties have scapes as long as those of the typical Monterey County form. At the type locality in Monterey County it was noted that plants with short and with long scapes, although having identical flowers, grew in separate colonies, and that longer pedicels always occurred on plants with shorter scapes.

Section 2. STELLARES. Flowers rather small; perianth-tube rounded or somewhat truncate at base, of tough texture, persistent and not splitting in fruit; perianth-segments rotately spreading; staminodia usually nearly or quite as wide as perianth-segments, involute but not undulate, obtuse and often emarginate; filaments very short, more or less channeled on the back; anthers deeply notched at both ends.

The dorsally channeled filaments constitute the most notable constant morphological feature of this section. However, a similar condition of the filaments is seen in *B. filifolia* and in *B. jolonensis*. *Brodiaea stellaris* shows several unique and very remarkable structural features but in general form of the flowers is very similar to *B. pallida*, as was stated in connection with the original description of that species. *B. stellaris* and *B. minor* show little superficial resemblance to each other, but *B. pallida* is in many respects intermediate between them.

Stamens without appendages; capsule short-ovoid, enclosed in the perianth-tube, the segments folded together above it.

Pedicels of first flowers rather long, horizontally spreading in fruit; perianth constricted at throat, the segments twice as long as tube; staminodia curved outward, 2 to 2.5 mm. wide; anthers 1.5 mm. wide .....4. *B. minor*

Pedicels of first flowers extremely short, not horizontally spreading; perianth not constricted at throat, the segments 1 to 1½ times as long as tube; staminodia erect, 3.5 to 4 mm. wide; anthers 3 mm. wide .....5. *B. pallida*

Stamens each with two dorsal appendages; capsule elongating and nearly equalling perianth; perianth-segments remaining expanded after withering.....6. *B. stellaris*

4. *Brodiaea minor* (Benth.) Wats., Proc. Am. Acad. 14:236. 1879.

B. grandiflora Smith var. *minor* Benth., Pl. Hartw. 340. 1857. *Hookera minor* Britten, Journ. Bot. **24**:51. 1886. *B. Purdyi* Eastw., Proc. Cal. Acad. ser. 2, **6**:427, pl. 58. 1896. *Hookera Purdyi* Heller, Muhl. **6**:83. 1910.

Corm nearly always without offsets; scape slender, 1 to 3 dm. tall; pedicels 1 to 6 cm. long, inclined to be horizontally spreading in fruit; perianth violet, the tube 5 to 8 mm. long, ovoid, markedly constricted at the throat, cartilaginous and opaque in fruit, not splitting, the segments 10 to 18 mm. long, narrowly oblong or the inner broadened toward apex, rotate, somewhat recurved; staminodia 7 to 10 mm. long, 2 to 2.5 mm. wide, as wide as perianth-segments or more often narrower, obtuse or retuse, sometimes with a faint brown midvein, strongly involute, closely folded around stamens at base but arcuate so that the tips are widely divergent; filaments 1 to 2 mm. long, slightly channeled on the back; anthers 4 to 6 mm. long, emarginate at apex, covered with minute processes; capsule short-ovoid.

Sacramento Valley and Sierra Nevada foothills from Shasta County to Amador County, California.

CALIFORNIA: Shasta Co.: 3 miles north of Redding, *Hoover 1191* (H); 5 miles east of Redding, *Hoover 1209* (H); Sheridan Creek, *Johannsen 105* (VT). Tehama Co.: 5 miles east of Red Bluff, *Eastwood and Howell 1884* (CA); Red Bluff, 1915, *L. E. Smith* (CA). Plumas Co.: Prattville, 1902, *Coombs* (UC). Butte Co.: Butte Meadows, *Heller 11619* (CA, OS, S, UC); Sutton House, *R. M. Austin 32* (UC); 3 miles north of Cana, *Hoover 1173* (H); 3 miles north of Chico, *Hoover 2237* (H); mesa east of Chico, *R. M. Austin 816* (UC); hills back of Chico, 1896, *Purdy* (CA, type of *B. Purdyi* Eastw.). Nevada Co.: Nevada City, *Eastwood 570* (CA); near Banner Hill, *Hall 10175* (UC); near Wolf Creek, *Eastwood 3425* (CA); Grass Valley, *Keck 1602* (S); near Kress, *Hoover 3621* (H); Bear Valley, 1898, *Jepson* (J). Sacramento Co.: Rio Linda, *Hoover 2205* (H). Eldorado Co.: White Rock Canyon, *Belshaw 2336* (VT); Mud Springs, *K. Brandegee* (UC); between Coloma and Rose Springs, 1911, *K. Brandegee* (UC); Sly Park, *Hall 11284* (CA). Amador Co.: 3 miles west of Ione, *Hoover 2409* (H).

The name *Brodiaea minor* was for some time subject to misapplication, being used principally in California for the species here treated as typical *B. coronaria*, but Hartweg's original collection of *B. grandiflora* var. *minor* Benth., on which *B. minor* was based, is said by Miss Alice Eastwood and by Dr. W. L. Jepson, both of whom have examined it, to be the present species. It was originally collected somewhere in the Sacramento Valley region. Watson's description of *B. minor* applies perfectly to this species, but Oregon was mentioned as within its range. It was also credited to Oregon in Howell's "Flora of Northwest America," perhaps on the basis of Watson's statement or perhaps through confusion with *B. coronaria*. The Rogue River Valley would seem to offer ideal habitats for this species, but no specimens from that region seen by the writer can be referred here.

Brodiaea minor usually grows in hard-packed clay or gravelly soil, often being associated with *B. californica* and flowering at the same time. At many localities in the Sacramento Valley it tends to grade toward var. *nana*, but in

the hills it is quite uniform. Although it is frequent on the east side throughout the length of the Sacramento Valley, no specimens have been seen from the west side south of Tehama County. The absence of offsets from the corms is very nearly a constant character in *B. minor*. The writer, during extensive field observations, has found no plants of this species bearing offsets, and only two collections have been seen in which they are present (*Hall 10175* and *Jepson* in 1898, cited above). The flowers of these collections are apparently typical of *B. minor*, but further knowledge of this form is desirable.

4a. **Brodiaea minor** (Benth.) Wats. var. **nana** comb. nov.

B. nana Hoover, Leafl. West. Bot. **1**:225. 1936.

Scape extending 1 to 5 cm. above the surface of the ground; perianth bluish lilac; all parts of the flower shorter than in typical *B. minor* but fully as wide; perianth-segments 8 to 15 mm. long, the inner varying to narrowly obovate; staminodia 5 to 7 mm. long; anthers 3 to 4 mm. long.

Plains of the Sacramento Valley, California, from Tehama County to Sacramento County, and low hills on the eastern border of the Great Valley from Butte County to Merced County.

CALIFORNIA: Tehama Co.: 6 miles south of Corning, *Hoover 2298* (H). Butte Co.: Durham, 1932, *Morrison* (CA); 5 miles southwest of Pentz, *Heller 11321* (OS, UC); 8 miles north of Oroville, *Heller 11321* (CA, S). Sacramento Co.: Del Paso, *Hoover 1133* (H); North Sacramento, *Ramaley 11192* (UC); Folsom, *Nordstrom 34* (VT). Calaveras Co.: Comanche, *Yates 5153* (UC, VT), *Belshaw 1982* (UC, VT). San Joaquin Co.: Farmington, *Hoover 1056* (H). Stanislaus Co.: Warnerville, *Hoover 1048* (H). Merced Co.: 5 miles north of Snelling, *Hoover 963* (CA, type of *B. nana* Hoover, UC), *2065* (S).

Because of its small size, paler flowers, and broader perianth-segments, this form in the field has an aspect different from typical *B. minor*. The differences obviously have a genetic basis, for the two kinds of plants both have a considerable range and show their characteristics independently of edaphic or seasonal conditions. Nevertheless, not long after the var. *nana* was described as a species, complete intergradation with typical *B. minor* was found to occur The specimens cited from Sacramento County are actually intermediate but nearer to the variety.

5. *Brodiaea pallida* Hoover, Leafl. West. Bot. 2:129. 1938.

Corm producing offsets abundantly; leaves expanded at base into membranous sheaths; scapes 1 to 3 dm. tall, usually several from a corm; pedicels ascending or spreading but not horizontal, those of the earlier flowers 5 to 10 mm. long, the young umbels thus congested, those of the later flowers becoming elongated, 2 to 6 cm. long; perianth pale lilac (darkening in drying), the tube cylindric with rounded base (in drying apparently constricted above), 7 to 10 mm. long, in fruit cartilaginous and opaque, the segments rotate, 10 to 15 mm. long; staminodia 7 to 10 mm. long, 3.5 to 4 mm. wide, fully as wide as the perianth-segments, involute, retuse, erect and loosely folded around the

stamens; filaments 2 mm. long, with strongly reflexed margins; anthers 4 to 5 mm. long, with incurved lobes at apex, covered with fleshy hair-like processes; capsule short-ovoid.

Known only from Chinese Camp, Tuolumne County, California.

CALIFORNIA: Tuolumne Co.: Chinese Camp, *Hoover 2375* (UC, type, CA, S), *2451* (H), *3616* (UC).

This species is apparently related to *B. minor*. The reflexed margins of the filaments and the peculiar hair-like processes on the anthers, while only slightly developed in *B. minor*, are well marked in *B. pallida*, although both features are obscured in drying. In the form of the perianth and the position of the staminodia, *B. pallida* differs considerably from *B. minor* and is quite similar to *B. stellaris*. This similarity between *B. pallida* and *B. stellaris* is not readily observable in dried specimens. The very short pedicels of the earlier flowers in *B. pallida* constitute a feature which is unique in the genus but in this species evidently quite normal, inasmuch as the plants in their native habitat were identical in two successive years with different weather conditions and have retained all their peculiarities under cultivation. Although this species reproduces vegetatively more vigorously than any other *Brodiaea*, it has been found only in one place. Here it grows along a small stream in hard-packed clay among volcanic rocks, associated with *B. elegans* and *B. coronaria*, neither of which seems closely related to it. Its occurrence is to be expected in similar situations in the surrounding region, particularly to the north.

6. *Brodiaea stellaris* Wats., Proc. Am. Acad. 17:381. 1882.

Hookera stellaris Greene, Bull. Cal. Acad. **2**:137. 1886.

Corm either with or without offsets; scape 1 to 4 dm. tall; pedicels ascending, 2 to 17 cm. long; perianth violet, the tube campanulate, 7 to 10 mm. long, in fruit firm-membranous, not splitting, the segments spreading, 10 to 13 mm. long; staminodia 4 to 6 mm. long, nearly as wide as perianth-segments, loosely folded around the stamens, involute, at apex hooded and retuse, at base with both margins abruptly inflexed, thus apparently constricted; filaments 2 mm. long, very broad, channeled on the back but with spreading margins, abruptly narrowed at apex, each bearing two appendages extending along the back of the anther; appendages broad, with the flat surfaces perpendicular to the surface of the anther; anthers 4 to 5 mm. long, deeply notched at apex; capsule at maturity fusiform, nearly equalling the expanded withered perianth, containing numerous seeds.

Humboldt County to Sonoma County, California, toward the interior in the Coast Ranges nearest the coast.

CALIFORNIA: Humboldt Co.: Lamb Ranch near head of South Fork of Yager Creek, *M. S. Baker 127b* (CA); head of South Yager, *Kildale 681* (S); McClellan Mountain, *Tracy 7024* (UC). Mendocino Co.: road above River Rest, *Eastwood 11489* (CA); near Yorkville, *Eastwood and Howell 4567* (CA). Sonoma Co.: Skaggs Springs, 1915, *Parsons* (CA); Graton-Occidental road, *M. S. Baker 208b* (S), *Hoover 3611* (UC); Occidental, *Hoover 4043* (UC).

Brodiaea stellaris is seldom collected and probably quite rare, although locally abundant in some places. As known to the writer, it grows in clay soil or on rocky slopes in openings of woods composed mainly of Douglas Fir and Redwood. So far as is known, it occurs only in a narrow zone from north to south, away from the immediate coast in the ranges nearest the ocean. The species was based on specimens collected near Ukiah by Purdy.

The appendages on the stamens of this species are very different from those found in the Appendiculatae and perhaps are not homologous. Aside from the mere possession of these appendages, there is no indication of close relationship between *B. stellaris* and the Appendiculatae. The peculiar characteristics of this species, particularly the structure of the stamens, are well represented by the figure in Abrams's "Illustrated Flora of the Pacific States." Nearly as remarkable as the features of the stamens and staminodia is the lengthening of the capsule, which apparently has not been noticed previously.

Section 3. APPENDICULATAE. Flowers large or medium-sized; perianth-tube cylindric, rounded at base, becoming brittle, longitudinally splitting in fruit; perianth-segments ascending or spreading, not recurved or only slightly so; staminodia closely folded around the stamens, involute, often undulate-denticulate; filaments angled or flattened; anthers bifid at apex; stamens frequently bearing two filiform undulate appendages on the back.

This distinctive group is of uncertain relationship, but the splitting of the perianth-tube in fruit, together with the usual absence of offsets from the corms, suggests an affinity with the Filifoliae, a seemingly more advanced group perhaps derived in some way from the Appendiculatae. *Brodiaea californica* and *B. appendiculata*, while not very similar superficially, are shown to be closely related to each other by several features of the flower.

Perianth-segments ascending, 2½ to 3 times as long as tube; staminodia 15 to 28 mm. long; anthers shortly bifid at apex, without a point in the sinus; stamen-appendages rudimentary or absent; capsule ovoid. .....7. *B. californica*

Perianth-segments spreading, 1½ to 2 times as long as tube; staminodia 8 to 12 mm. long; anthers with two long lobes at apex and a median tooth in the sinus; stamen-appendages well developed; capsule subglobose....8. *B. appendiculata*

7. *Brodiaea californica* Lindl., Journ. Hort. Soc. 4:84. 1849.

B. grandiflora Smith var. *elatior* Benth., Pl. Hartw. 339. 1857. *B. grandiflora* Smith var. *major* (Benth. acc. to) Baker, Journ. Linn. Soc. **11**:377. 1871. *Hookera californica* Greene, Bull. Cal. Acad. **2**:136. 1886.

Corm large, without offsets in the typical form; scape 2 to 5 dm. tall, often scabrous; pedicels ascending, 2 to 12 cm. long; perianth lilac to violet or rarely pink, the tube rounded at base, 8 to 12 mm. long, in fruit firm-membranous and brittle, the segments 20 to 35 mm. long, ascending, often slightly recurved; staminodia narrow, 15 to 28 mm. long, closely folded around the stamens, usually spreading slightly at apex, the margin involute, undulate-denticulate or entire, at apex rounded and often slightly emarginate; stamens a little shorter than the staminodia; filaments angular, 6 to 10 (or rarely 15) mm. long, sometimes with two minute undulate appendages extending from apex. anthers 9 to 13 mm. long, with a short narrow notch at apex; capsule ovoid.

Shasta County, California, southward in the Sacramento Valley to Butte County and in the Sierra Nevada to Nevada County.

CALIFORNIA: Shasta Co.: 7 miles north of Redding, *Eastwood and Howell 2738* (CA); Redding, *Heller 7844* (S, UC), *L. E. Smith 728* (CA); 4 miles north of Anderson, *Hoover 1212* (H); northeast of Cottonwood on road to Viola, 1935, *Rowntree* (CA). Tehama Co.: 4 miles south of Cottonwood, *Hoover 1181* (H); Red Bluff, 1917, *Wickes* (CA); 4 miles north of Corning, *Hoover 2297* (H). Butte Co.: 3 miles north of Cana, *Hoover 1172* (H); De Sabla, 1917, *Edwards* (S); 1 mile west of Richardson Springs, *Keck 2410* (S); Little Chico plains, *Bruce 2126* (S); 2 miles north of Chico, *Hoover 2233* (H); Bidwell Park, 1923, *Purnell* (S); Iron Canyon, *R. M. Austin 45* (UC); 8 miles north of Oroville, *Heller 11389* (CA, OS, S, UC). Yuba Co.: 2 miles west of Dobbin, *Elvin 50* (VT); Indiana Ranch, *Elvin 46* (VT). Nevada Co.: near San Juan on road from Nevada City, *MacFadden 12577* (CA); Nevada City, *Eastwood 565* (CA); Grass Valley, *Keck 1601* (S), *Heller 8097* (S, UC); near Wolf Creek, *Eastwood 3426* (CA); near Kress, *Hoover 3620* (H).

The original description and figure of *Brodiaea californica* apply well in most respects to the plant here treated as that species, although the perianth-segments are represented as more widely spreading than usual. However, the statement that "it is easily increased by offsets from the old bulbs" is made under the original description, whereas no plants of this species with offsets are now known to occur in the Sacramento Valley, where Hartweg collected the original specimens. In this connection, it is notable that Lindley in the same article where *B. californica* was described also stated that *Cyclobothrya monophylla* (now known as *Calochortus monophyllus*) is increased by offsets from the old bulbs. In its native habitat that species never produces offsets. This circumstance makes it appear probable that a similar error was made in regard to *Brodiaea californica*, although there is a slight possibility that species which do not multiply by offsets in California might do so under different conditions, as in England. Because of these considerations, the name *B. californica* is here continued in its customary sense. Bentham cited it in synonymy when describing *B. grandiflora* var. *elatior*, which is therefore necessarily synonymous. The exact locality where the species was originally collected is shown by a study of Hartweg's journal to be near the present settlement of Cana, Butte County, according to Dr. W. L. Jepson.

This species grows both on wooded hills and on open plains and flowers from May to July, depending on the conditions of the particular locality. It is variable in regard to some of the characters which in other species are constant. In 1936, a rather dry year in California, the writer made three collections of *B. californica* in the Sacramento Valley, all of which showed stamen-appendages, minute but still evident, of the sort found in *B. appendiculata*. The following year, when moisture was more plentiful, two collections made in the same region showed no trace of such appendages. Well developed appendages were again observed in 1939, an exceptionally dry year in that region. All plants of this species observed in the Sacramento Valley have staminodia with undulate-denticulate margins as in *B. appendiculata*. The plants from Nevada County, a region of high precipitation, have staminodia with entire margins, and stamen-appendages are absent. The corms of *B. californica* are similar to those of *B. appendiculata* but have thinner coats and

are less deeply seated. These observations indicate that *B. appendiculata* may have originated from *B. californica* or from its immediate ancestor in response to arid conditions, which to some degree seem to induce the development in *B. californica* of certain characteristics of the related species.

7a. **Brodiaea californica** Lindl. var. **leptandra** (Greene) comb. nov.

Hookera leptandra Greene, Pitt. **1**:74. 1887. *B. leptandra* Baker, Gard. Chron. ser. 3, **20**:213. 1896. *Hookera synandra* Heller, Bull. S. Cal. Acad. **2**:65. 1903. *B. synandra* Jepson, Fl. Cal. **1**:288. 1922, as to name only.

Corm shallowly seated, bearing offsets; margins of staminodia entire; stamen-appendages completely absent; capsule frequently smaller.

Sonoma and Napa Counties, California, away from the coastline.

CALIFORNIA: Sonoma Co.: 2 miles southeast of Healdsburg, *Hoover 3604* (CA); Petrified Forest, *Heller 5742* (S, isotype of *Hookera synandra* Heller); near Maple Glen, 1904, *M. S. Baker* (UC); Adobe Canyon above Kenwood Springs, *M. S. Baker 234* (S), *234a* (S), *234b* (UC), *2213a* (S). Napa Co.: Four Corners, Howell Mountain, *Jepson 17634* (J).

The only constant difference between the form of *B. californica* found in Sonoma County and that found in the Sacramento Valley and adjacent mountains is the presence of offsets in the former. Ordinarily this difference would not be regarded as a basis for nomenclatorial distinction, but in this species the two forms are separated by a considerable extent of territory where the species is not represented. *Hookera leptandra* Greene was based on a collection made by Parry near Calistoga, Napa County.

8. *Brodiaea appendiculata* Hoover, Madroño 4:130. 1937.

Corm large, deep-seated, without offsets, with very heavy fibrous coats which extend as a sheath around the subterranean portion of the scape and leaves; scape rather stout, 1 to 4.5 dm. tall; pedicels 3 to 10 cm. long, widely divaricate in fruit; perianth-tube 8 to 10 mm. long, in fruit brittle, with the texture of isinglass, readily splitting; perianth-segments straight (that is, not recurved), 15 to 20 mm. long, deep violet-purple, the outer oblong, acute, the inner broader and obtuse; staminodia linear, obtuse or retuse, 8 to 12 mm. long, with involute and undulate-denticulate margins, approximate around the anthers; stamens considerably shorter than the staminodia; filaments 4 to 5 mm. long, flattened, bearing at apex two filiform undulate appendages 3 to 5 mm. long which extend along the backs of the anthers; anthers 7 to 8 mm. long, deeply notched at both ends, with a median tooth in the apical notch; capsule subglobose with acute apex.

East side of the Great Valley of California and bordering low foothills from Sutter County to Madera County; also very local in the Coast Ranges from Napa County to Santa Clara County.

CALIFORNIA: Sutter Co.: 2 miles south of Rio Oso, *Hoover 2227* (UC); Pleasant Grove, *Hoover 2215* (CA, S). Placer Co.: Lincoln, *Hoover 4089* (CA, UC). Sacramento Co.: Sacramento, *Hoover 1130* (H, J); Scott Ranch, *Nordstrom 43* (UC,

VT). Amador Co.: Buena Vista, *Jepson 9957* (J), *9965* (J). Calaveras Co.: near Valley Springs, *Stanford 310* (OS); near Jenny Lind, 1923, *Steinbeck* (CA). San Joaquin Co.: Linden, 1896, *Gunnison* (UC); near Peters, *Stanford 952* (S); Farmington, *Hoover 1058* (UC). Tuolumne Co.: Bear Creek, *Williamson 49* (CA, S); Keystone, *Hoover 4069* (CA, UC). Stanislaus Co.: Warnerville, *Hoover 1040* (J, type, CA, UC), *2047* (S); 2 miles south of Oakdale, *Hoover 2027* (CA); 4 miles south of Oakdale, *Hoover 1020* (UC); near La Grange on Snelling road, *Hoover 2052* (H); Montpellier, *Hoover 590* (H). Merced Co.: Hayward, *Carlson 399* (UC, VT); 5 miles north of Snelling, *Hoover 964* (UC); Merced Falls, *Eastwood 4384* (CA); 7 miles north of Merced, *Hoover 2073* (H); 4 miles north of Merced, *Hoover 1079* (UC). Madera Co.: Daulton, *Hoover 3455* (H); Madera, *Hoover 979* (UC). Napa Co.: mouth of Sage Canyon, Napa Valley, *Jepson 9981* (J). San Mateo Co.: Cedro field near Stanford University, 1922, *Bacigalupi* (S). Santa Clara Co.: 3¾ miles east of New Almaden, *Belshaw 2257* (VT).

Brodiaea appendiculata is characteristic of low open hills and plains, growing in soil which becomes baked very hard by the sun during the flowering season in April and May. The corms are remarkable for their thick sheathing coats and are often as far beneath the surface of the ground as the scapes extend above. This species is confined to low altitudes to a more marked degree than any other *Brodiaea*. There is no record of its occurrence above 1800 feet.

The characters of the apex of the anthers and the shape of the capsule readily differentiate *B. appendiculata* from all forms of *B. californica*. The figure accompanying the original description of *B. appendiculata* is erroneous in omitting to show the tooth in the middle of the broad sinus between the terminal anther-lobes. This species is common and often locally abundant in the main part of its range. In the Sacramento Valley the Marysville Buttes mark a definite boundary between the range of *B. californica* to the north and that of *B. appendiculata* to the south. The sparing occurrence of this species at a few localities in the Coast Ranges seems peculiar, but the plants seem identical with those of the east side of the Great Valley.

Section 4. FILIFOLIAE. Corms without offsets; flowers small; perianth-tube rounded at base, in fruit thin-membranous, splitting and readily deciduous; perianth-segments ascending or spreading, not recurved or only slightly so; staminodia plane, narrow and acuminate, or absent; filaments angled or with reflexed margins; anthers shortly bifid or entire at apex.

Although very different in certain details of flower structure, the two species included in this group are clearly more closely related to each other than to the other members of the genus. Both are said to grow in moist adobe soil. Morphologically these species are the most highly specialized in the genus. The membranous brittle perianth-tube in fruit suggests an affinity with the Appendiculatae, but the condition as seen in that section is in the Filifoliae much more pronounced. The reflexed margins of the filaments in *B. filifolia* are suggestive of the Stellares, while in *B. Orcuttii* the pedicels show a tendency to spread horizontally in fruit in a manner reminiscent of *B. appendiculata* and *B. minor*. Another affinity is suggested by the similarity of the stamens of *B. filifolia* to those of *B. jolonensis*.

Perianth-segments spreading; staminodia present; filaments very short, flattened, channeled on the back ..... 9. *B. filifolia*

Perianth-segments ascending; staminodia absent; filaments elongated, angular. ..... 10. *B. Orcuttii*

9. *Brodiaea filifolia* Wats., Proc. Am. Acad. 17:381. 1882.

Hookera filifolia Greene, Bull. Cal. Acad. **2**:138. 1886.

Corm without offsets; scape slender, 2 to 4 dm. tall; pedicels slender, spreading, 1.5 to 5 cm. long; perianth-tube greenish, slender-campanulate, 6 to 7 mm. long, in fruit becoming thin-membranous and readily splitting; perianth-segments violet, 9 to 12 mm. long, spreading, slightly recurved at apex; staminodia plane, narrowly linear, tapering from the base, 6 to 7 mm. long, curved outward both at base and at apex, the middle portion erect, standing apart from the stamens (shrivelling in drying and then hardly 2 mm. long); filaments 1 mm. long, not extending below the basal lobes of the anthers, broadly triangular, channeled on the back, joined with the bases of the staminodia on either side; anthers broad, 4 mm. long, emarginate at apex; capsule short-ovoid.

Southern California from the San Bernardino Valley to San Diego County.

CALIFORNIA: Los Angeles Co.: foothills north of Glendora, *Davidson 3418* (S); San Clemente Island, mesa summit, *Murbarger 219* (UC). San Bernardino Co.: Arrowhead Hot Springs, *G. B. Grant 6631* (CA, S), *S. B. and W. F. Parish 186* (S), 1886, *Parish* (UC), 1890, *Parish* (UW), 1906, *G. B. Grant* (UC), *Spencer 1139* (CA); San Bernardino Mountains, *S. B. and W. F. Parish 786* (UC); vicinity of San Bernardino, *Parish 3669* (UC); San Bernardino Valley, *Wright 1792* (UC). Riverside Co.: 1 mile east of Perris, *Munz and Johnston 5412* (CA, UC), *Peirson 8772* (UC); 2 miles south of Perris, *J. T. Howell 4790* (CA, UC). San Diego Co.: 4.5 miles south of Vista, 1938, *Gander* (H).

This species has been found only in a few scattered localities and is apparently rare. It grows on flats in heavy clay soil and flowers in May and early June. The original description was based on plants collected near San Bernardino by Parish. The form of the staminodia of this species is unique. They have consistently been described as shorter than the stamens, but examination of fresh flowers received from Mr. Frank F. Gander, together with subsequent study of the same specimens after drying, shows that to be an error resulting from study of dried specimens only. The anthers, also, are not actually "sessile" as described, although the short filaments are not evident on the inner side.

10. *Brodiaea Orcuttii* (Greene) Baker, Gard. Chron. ser. 3, 20:214. 1896.

Hookera Orcuttii Greene, Bull. Cal. Acad. **2**:138. 1886. *B. filifolia* Wats. var. *Orcuttii* Jepson, Fl. Cal. **1**:288. 1922. *Hookera multipedunculata* Abrams, Bull. Torr. Club **32**:537. 1905.

Corm rather large, without offsets; scape 1 to 4 dm. tall; pedicels slender, 2 to 8 mm. long, in fruit horizontally spreading; perianth violet, the tube 5 to 8 mm. long, in fruit thin-membranous and brittle, the segments ascending,

10 to 18 mm. long; staminodia absent; filaments slender, angular, 4 to 6 mm. long; anthers narrow, 5 to 6 mm. long, the apex entire or nearly so; capsule short-ovoid.

San Diego County, California, where it is apparently common.

CALIFORNIA: San Diego Co.: Rainbow Valley, *Gander 5785* (SD); 30 miles north of San Diego, *Orcutt 691* (UC); Henshaw Dam, 1926, *M. E. Jones* (CA, S); 4 miles west of San Marcos, *Gander 2590* (SD); Santa Ysabel, *Parish 4413* (S); Cuyamaca Lake, *Abrams 3897* (CA, S, UC, isotypes of *Hookera multipedunculata* Abrams); Linda Vista, *Spencer 78* (UC), *Gander 5483* (SD); head of Murphy Canyon, *Gander 1961* (SD); mesa north of San Diego, *Chandler 5325* (S); 5 miles north of San Diego, *Abrams 3447* (S); San Diego, *T. Brandegee (C. F. Baker 1661)* (CA, UC), *Meyer 140* (UC); Woodwardia Canyon, Otay Mountain, *Gander 2611* (SD).

Although limited in distribution, this species is evidently of more common occurrence than *B. filifolia* and has a considerable altitudinal range, growing as high as 4700 feet. The original description was based on plants collected by Orcutt near San Diego and also thirty miles to the north. The fresh flowers seen by the writer, collected by Mr. Frank F. Gander on Kearney Mesa and near San Marcos, showed no trace of staminodia. According to Mr. Gander, this species grows "near streams, in seepage areas, and in beds of vernal pools" (Madroño 4:163). It flowers from late April to July, depending upon altitude and seasonal conditions.

EXCLUDED NORTH AMERICAN SPECIES

The writer intends in the near future to complete revisional studies of *Dichelostemma* and *Triteleia*. Because of certain difficulties of classification, it does not seem advisable at this time to refer the members of those genera to any definite species.

Brodiaea bicolor Suksd.—Triteleia.
Brodiaea breviflora (Wats.) Macbr.—Androstephium breviflorum Wats.
Brodiaea Bridgesii Wats.—Triteleia.
Brodiaea candida (Greene) Baker—Triteleia.
Brodiaea capitata Benth.—Dichelostemma
Brodiaea coccinea Gray—Dichelostemma.
Brodiaea coerulea (Scheele) Macbr.—Androstephium coeruleum (Scheele) Greene.
Brodiaea congesta Smith—Dichelostemma
Brodiaea crocea (Wood) Wats.—Triteleia.
Brodiaea dissimulata Peck—Triteleia.
Brodiaea Douglasii Wats.—Triteleia.
Brodiaea gracilis Wats.—Triteleia.
Brodiaea grandiflora (Lindl.) Macbr. (not Smith)—Triteleia.
Brodiaea grandiflora Smith *a. macrantha* Torr. ex Wood, Proc. Acad. Philad. 1868: 172. 1868. Not possible to determine from description; perhaps B. elegans Hoover.
Brodiaea Hendersoni Wats.—Triteleia.
Brodiaea Howellii Wats.—Triteleia.
Brodiaea hyacinthina (Lindl.) Baker—Triteleia.
Brodiaea Ida-maia (Wood) Greene—Dichelostemma.
Brodiaea insularis Greene—Dichelostemma.
Brodiaea ixioides (Ait. f.) Wats.—Triteleia.
Brodiaea lactea (Lindl.) Wats.—Triteleia.
Brodiaea laxa (Benth.) Wats.—Triteleia.
Brodiaea Leachiae Peck—Triteleia.
Brodiaea Lemmonae Wats.—Triteleia.
Brodiaea lilacina (Greene) Baker—Triteleia.
Brodiaea lugens (Greene) Baker—Triteleia.
Brodiaea modesta Hall—Triteleia.
Brodiaea multiflora Benth.—Dichelostemma.
Brodiaea Palmeri Wats.—Triteleia (?).
Brodiaea parviflora T. & G.—Dichelostemma.
Brodiaea Paysonii A. Nels. Referred by

Rydberg in "Flora of the Rocky Mountains and Adjacent Plains" to Androstephium breviflorum Wats.

Brodiaea peduncularis (Lindl.) Wats.—Triteleia.

Brodiaea pulchella (Salisb.) Greene—Dichelostemma.

Brodiaea scabra (Greene) Baker—Triteleia.

Brodiaea venusta Greene—Dichelostemma

Brodiaea volubilis (Kell.) Baker—Dichelostemma.

Excluded South American Species

It is evident that none of the following is actually a true *Brodiaea*, but before these species can be placed in any other genus, field work will be necessary to determine their relationships with other South American genera.

Brodiaea Ameghinoi Speg.
Brodiaea aurea (Lindl.) Macloskie.
Brodiaea Berteri (Kunth) Fuentes
Brodiaea bivalvis (Lindl.) Meigen.
Brodiaea brevipes (Kunth) Baker.
Brodiaea circinata Sandwith.
Brodiaea Felipponei Herter.
Brodiaea Gaudischaudiana (Kunth) Fuentes.
Brodiaea gracilis (Phil.) Fuentes.
Brodiaea hirtella (Kunth) Baker.
Brodiaea Leichtlinii Baker.
Brodiaea Luzula Macloskie.
Brodiaea nivalis (Poepp.) Baker.
Brodiaea patagonica Baker.
Brodiaea Philippiana Baker.
Brodiaea Poeppiggiana (Gay) Kurtz.
Brodiaea porrifolia (Poepp.) Meigen.
Brodiaea recurvifolia Wright.
Brodiaea Sellowiana (Kunth) Baker.
Brodiaea sessiliflora Baker.
Brodiaea sessilis (Phil.) Meigen.
Brodiaea setacea Baker.
Brodiaea Speggazinii Macloskie.
Brodiaea subbiflora (Colla) Baker.
Brodiaea Tweedieana (Baker) Hicken.
Brodiaea uniflora (Lindl.) Engler.
Brodiaea violacea (Kunth) Baker.
Brodiaea viridior Killip.
Brodiaea vittata (Griseb.) Baker.

REFERENCES

Abrams, L. R. 1923—Illustrated Flora of the Pacific States, **1**:399-410.

Baker, J. G. 1871—Revision of the Genera and Species of Herbaceous Capsular Gamophyllous Liliaceae. Journ. Linn. Soc. **11**:349-436.

———1896—The Genus Brodiaea and Its Allies. Gard. Chron. ser. 3, **20**:213-214, 238-239, 459, 687.

Greene, E. L. 1886—Some Genera Which Have Been Confused under the Name Brodiaea. Bull. Cal. Acad. **2**:125-144.

Hoover, R. F. 1939—A Definition of the Genus Brodiaea. Bull. Torr. Club **66**: 161-166.

Jepson, W. L. 1922—Flora of California, **1**:282-291.

Johansen, D. A. 1932—The Chromosomes of the Californian Liliaceae, I. Am. Journ. Bot. **19**:779-783.

Watson, S. 1879—Revision of the North American Liliaceae. Proc. Am. Acad. **14**:213-288.

Mexican Involucrate Trifoliums

Alice Vaughan

Although the Mexican involucrate Trifoliums are related to the southern Rocky Mountain *Trifolium Fendleri,* there is a distinct hiatus between the Mexican plants and even the Trifoliums of Arizona and New Mexico, not a single species being common to the two areas. The writer has seen a considerable series of Arizona Trifoliums, but with the exception of a specimen from Huachuca Mountains, Cochise Co., which of course are near the Mexican boundary and are floristically strongly related to Mexico, these plants represent different species than the Mexican involucrate Trifoliums. The latter group, therefore, are treated as follows:

KEY TO THE MEXICAN INVOLUCRATE TRIFOLIUMS

Plant more than 10 cm. high; upper leaves more than 2 cm. long.
Plant 40-80 cm. high; stem 2-4 mm. in diam. ..... 1. *T. fistulosum*
Plant 10-30 cm. high; stem less than 2 mm. in diam. ..... 2. *T. Ortegae*
Plant less than 10 cm. high; upper leaves less than 2 cm. long.....
..... 2a. *T. Ortegae f. pumilum*

1. **Trifolium fistulosum** sp. nov.

T. fistulosum based on Bourgeau 75, collected in the "Vallie de Mexico á Contrason .... 1863-1866." Type in the Gray Herb.

Herba glabra erecta, 40-80 cm. alta; caules 2-4 mm. in diam. ad basin, fistulosi, lineati et saepe reticulato-rugulosi, aliquantum ramosi; stipulae amplae, foliaceae, marginibus dentatis vel laciniatis, apicem versus subulatis; foliola fere lanceolata, acuminata, serrulata, perspicue venosa, plerumque 3-4 cm. longa; capitula circiter foliam aequantes, globosa, 3-4 cm. lata; involucrum saepe 10-divisum; flores magni purpurei, numerosi; calyx perspicue 10-nervatus, 8-10 mm. longus, firme venosus; corolla 17-20 mm. longa, marcescens; legumen 4-spermum, semina optime magna, plana.

Tall glabrous erect perennial, 40-80 cm. high, with one to several annual shoots from a slender finely branched whitish root; stems 2-4 mm. in diam., hollow, firmly grooved longitudinally, often with conspicuous cross ridges, somewhat branched, the branches erect or ascending; leaves cauline, the petioles 1-2 times the length of the leaflets, grooved longitudinally; the stipules large, sheathing, foliaceous, sharply dentate or laciniate, the apex subulate; leaflets linear to narrowly lanceolate, acuminate, sharply serrulate, conspicuously veined (2 or) 3-4 (or 5) cm. long; head scarcely exceeding the leaves, globose, 3-4 cm. in diam., the involucre usually 10-lobed, the lobes laciniate into unequal subulate teeth, the flowers large, numerous; calyx conspicuously 10-nerved, the veins prominent, the tube peculiarly white, the teeth green or notably dark

purple, subulate, twice the length of the tube; corolla twice as long as the calyx, 17-20 cm. long, purple, withering early and persistent; pod 4-seeded, the seeds large, flat.

Southern Arizona (Cochise Co.) south along the Sierra Madre Occidentál to Michoacan and Hidalgo, Mexico, at elevations of 6000 to 8000 feet. June-Sept.

Specimens examined: MEXICO. Chihuahua: Sierra Madres near Colonia Garcia, *C. H. Townsend & C. M. Baker 145;* Durango: Durango, *Palmer 238;* Hidalgo: Honey Station, *Pringle 10302;* Michoacan: Morelia, *Arsene 5833, 5481, 9709;* Mexico: "Vallie de Mexico a contrason," *Bourgeau 75* (exsiccatae widely distributed in European herbaria, cf. de Candolle, *Phytographie* 399. 1880); sine loco, *Hartweg sine numero* (Gray Herb.). ARIZONA: Cochise Co.: Huachuca Mts., *Lemmon 2696* (USNH).

This plant has been lumped with the other Mexican involucrate Trifoliums under the name of *T. involucratum.* Hemsley (Biologia Centrali-Americana 1:232. 1880) cites for *Trifolium involucratum* both *Parry & Palmer 135* and *Bourgeau 75,* the former a very much dwarfed plant less than three inches high, probably an ecad of *Trifolium Ortegae,* while the latter has been arbitrarily selected as the type of *T. fistulosum* herein described as new, one of the largest of the North American Trifoliums. It is most certainly a distinct species, its diagnostic characters being the notably large hollow stem, the long linear leaflets and the conspicuously sheathing stipules. Since the concept of *Trifolium involucratum* Ortega, a homonym necessarily replaced by the name *T. Ortegae* Greene, best corresponds to another plant of this involucrate group, this species, although collected widely, has remained unnamed until the present time. *Palmer 238* and *Pringle 10302* are apparently plants intermediate between *T. fistulosum* and *T. Ortegae,* possibly natural hybrids between two species.

2. *Trifolium Ortegae* Greene

T. Ortegae Greene, Pittonia 3:186. 1897, based on *T. involucratum* Ortega, Horti Reg. Botan. Matrit. 33. 1797, in turn based on a garden plant grown at Madrid from seed sent by Sesse and Mociño, said to have been collected in Cuba, but see beyond *Pringle 1209,* coll. in "springy places, Sierra Madre," state of Chihuahua, Sept. 1887, here selected as a lectotype (Phil. Acad. Nat. Sci. Herb.). Not *T. involucratum* Lam., 1778.

Glabrous biennial or short-lived perennial, 10-30 cm. high, from a much-branched often whitish fibrous root; stems ascending or spreading, much-branched, hollow, grooved longitudinally, 2 mm. or less in diam.; leaves numerous, the petioles slender, 1-2 times the length of the leaflets, the stipules long, slender, sheathing, laciniate, the apex subulate, the upper leaflets 2-3 cm. long, linear to linear-lanceolate, the lower smaller, often oval to obovate or obcordate, serrulate, acuminate, strongly veined; heads usually borne above the leaves, about 15-40 flowered, globose, the involucre about 10-lobed, the lobes reduced, divided nearly to the base, simple and subulate, or larger and laciniate into 2 or 3 subulate divisions; calyx strongly 10-nerved, the 5 main

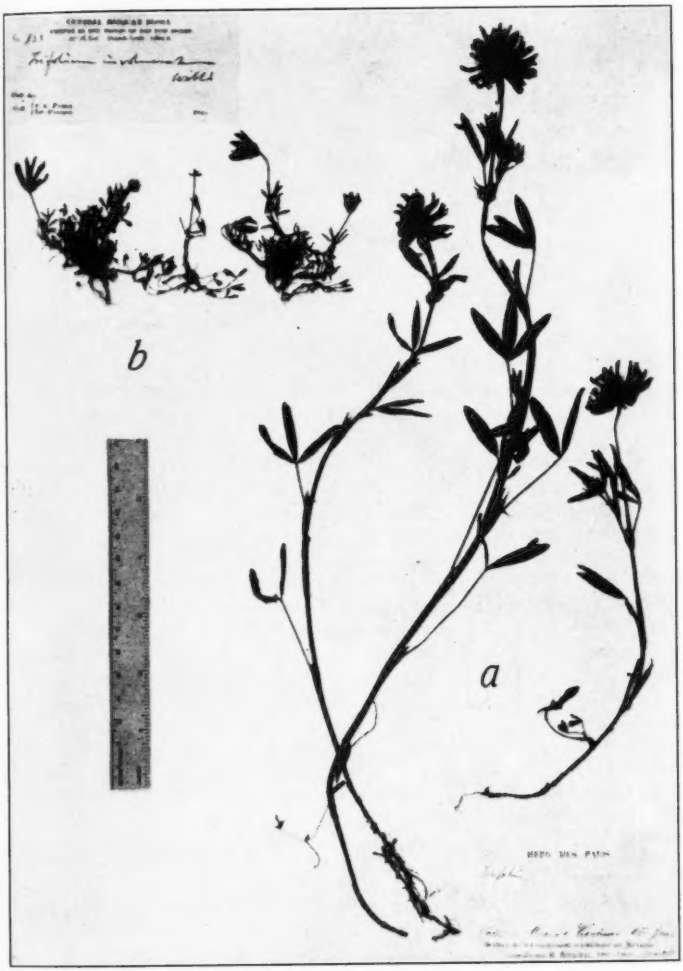

Fig. a. *Trifolium fistulosum* Vaughan, type in Gray Herb. Fig. b. *T. Ortegae* Greene f. *pumilum* Vaughan, type in Gray Herb.

nerves ridged, the tube peculiarly white, campanulate, the teeth about equalling the tube, subulate, green or strikingly dark purple; corolla 2-3 times the length of the calyx, reddish-purple, withering early and persistent, 13-16 mm. long; pod 4-7 seeded.

Wet places, especially stream banks, of northern Mexico.

Specimens examined: MEXICO. Chihuahua: Sierra Madre, *Pringle 1209* (lectotype, Phila. Acad. Nat. Sci. Herb., duplicate lectotype, NYBG); Memelichi, Rio Mayo, *H. S. Gentry 2803;* Loreto, Rio Mayo, *H. S. Gentry 2575;* Batapolas, *Palmer 309;* Coahuila: Chojo Grande, *Palmer 343;* San Luis Potosi: Morales, Moralos probably modern equivalent, *J. G. Schaffner 807.*

The original description of *Trifolium involucratum* Ortega says, "Habitat in Insula Cuba," but it seems certain that Mociño never collected in Cuba, while he did collect extensively in Mexico, even reaching Chihuahua (cf. Standley in Contr. U. S. Nat. Herb. 23:14. 1920; further notes upon Mociño by Hemsley in Biol. Cent.-Amer. 4:120. 1879). The name *Trifolium involucratum* has been widely misapplied to almost every species of the involucrate series in western North America. By careful comparison of the Mexican collections with Ortega's original description, as transcribed by McDermott, a group of plants has been found which corresponds point by point with his *Trifolium involucratum.* Of this group *Pringle 1209* has been selected as the lectotype because these specimens are widely distributed and rather easily accessible in herbaria. Caution must be used, however, in drawing conclusions from one sheet of Pringle's collection, because the concept of the species is gathered not from one specimen, but from an examination of several. For instance, the *Pringle 1209* in the Herbarium of the Academy of Natural Sciences at Philadelphia shows a predominantly oval or obovate leaflet shape which is not typical, but does show very well the much-branched habit and white roots. The *Pringle 1209* in the herbarium of the New York Botanical Garden shows the typically linear leaves, but the involucre is much reduced in comparison with that of the group. The only respect in which these plants differ at all from the original description of *T. involucratum* is in the proportion of the calyx to the corolla in some of them. The original description states the corolla to be three times as long as the calyx. In *Pringle 1209* some of the flowers have the corolla three times the length of the calyx, while others on the same plant are only twice as long.

McDermott (p. 62) uses a drawing of a leaf from *Pringle 1209* to illustrate *T. triaristatum* forma *pinetorum* (Greene) McDerm. The concept which *Pringle 1209* represents is entirely different from that of either *T. pinetorum* Greene (possible isotype, *Greene,* 14 IX 1880, from Pinos Altos Mts., New Mexico, examined. PH) or *T. triaristatum,* a Chilean species.

2a. **Trifolium Ortegae** f. **pumilum** f. nov.

T. Ortegae f. *pumilum* based on *Palmer and Parry 135,* from the region of San Luis Potosi, altitude 6000 ft., 1878. Type in Gray Herb.

Herbae pusillae, 4-10 cm. altae; caules tenues; foliola lanceolata vel linearia,

5-10 or 20 mm. longa; capitula parviora; flores 16-20; corollae calyci duplo longiores; legumen 4-6 spermum.

Similar to the species, but very much dwarfed, with fewer flowers to the head. Plant 4-10 cm. high; stems slender, the internodes very short; leaflets 5-10 (or 20) mm. long, lanceolate or linear; flowers of the same size as the species, but with fewer (16-20) in a head; corolla 2-2½ times the length of the calyx; pod 4-6 seeded.

Coahuila, San Luis Potosi and Guanajuato. Dry places.

Specimens examined: MEXICO: Coahuila; Saltillo, *Palmer no. x*, VII 1880; Guanajuato: without further locality, *A. Duges 12*.

This plant is designated as a form of *T. Ortegae* Greene because, although the flower parts are of the same size and shape as the species, there are fewer flowers to the head and the herbage is extremely dwarfed. It may represent an ecad of dry ground. This hypothesis is borne out by the fact that the species grows in wet places, while this form is found in "lieu non humide" *(Duges 12)*.

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Host-Parasite Catalogue of the Helminths of Ducks

W. Carl Gower

Introduction

That ducks, both wild and domestic, are of considerable economic importance is not to be questioned. Millions of dollars are spent each year by hunters, and the economic value of domestic ducks is considerable. For a number of years the numbers of wild ducks have steadily declined, and during the drought years, the population reached such a low level that a general alarm was sounded. Since that time, much activity has been pointed at learning the causes and remedies for the situation. While the problem of diseases and parasites has been considered, it has been worked on very little, especially at the breeding grounds among young ducks, and consequently, our knowledge of its importance is very limited. Ducks, being for the most part aquatic feeders, are particularly subject to helminthic infection. In areas where large numbers congregate to nest and raise young, this factor is considerable in importance. What effect such helminthic infections may have on the total duck population is unknown. The probable degree of infection is more or less in direct proportion to the crowding during the nesting and rearing period, and in drought years when other factors are most adverse to rearing young, this factor also would reach its peak of importance.

The host-parasite relationship of ducks and their helminth parasites is influenced by many factors. Ducks, both as individuals and as a group, show remarkable ability to harbor parasites with little or no inconvenience to themselves. Relatively few of the ducks that have been examined by the writer have been entirely free of helminths. Too, some 260 species of worms have been recorded in the literature from this group of birds, and is an extensive fauna to say the least. A careful examination of the following host-lists will indicate that, for the majority of helminths, there is little, if any physiological host specificity among species of ducks. Such parasitic limitation as is evident can, in most cases, be explained on the basis of physical reasons, such as inaccessibility of infective larvae to certain species by reason of feeding habits. It is self evident that of such a large group of helminth parasites, relatively few of the species are of any considerable degree of importance as pathogenes. The most important consideration from this standpoint is the potential pathogenicity of any parasite, and the probable greater degree of damage in the young host.

The habits of the hosts play a very important role in the relationships. The annual migration serves to disseminate the parasites, and of especial importance is the cross migration and wandering of the birds following the breeding season and preceeding the beginning of the fall migration. This allows for widespread dissemination of the parasites over the breeding grounds. Of some importance, is the proven fact that ducks may act as reservoir hosts

and vectors in the spread of certain parasites of domestic poultry. This is more often the case with tame and semi-tame ducks than with wild ones, but it is not at all uncommon to see wild ducks on farm ponds during the fall and spring migrations.

The reports on duck helminths are very widely scattered in the literature, due to the fact that ducks have been rather easily available to parasitologists for examination. Large numbers have been examined because they were available, and possibly because of economic reasons. This fact explains in some degree the large number of worms reported.

The following check-list has been compiled almost entirely from the literature. It is divided into two principal sections, the first lists the species of worms together with their synonyms, hosts, distribution, and references; the second lists the hosts with their synonyms and species of worms recorded from each. A key has been prepared for the families of each group, and for the genera of each of the families of helminths. Only a few of the more important and more recent references have been listed under each species.

The nature of such a check-list as this makes it a certainty that there will be errors and omissions. The author invites communication regarding such errors and omissions.

Indebtedness is expressed to Dr. S. C. Whitlock, Pathologist, Game Division, Michigan Department of Conservation, who has made many helpful suggestions during preparation of the manuscript; to Mr. H. D. Ruhl, Chief, Game Division, Michigan Department of Conservation, whose constructive policy has made possible the completion of the manuscript; and to Dr. Herbert Friedmann, Curator of Birds, United States National Museum, who has supplied the correct host names. The monographs of Ransom and Cram, dealing with the cestodes and nematodes of birds respectively, have been drawn upon rather freely in the preparation of the lists as well as the keys for these two groups.

Part 1

Key to Classes of Helminths

1. Body flattened; organs of attachment usually in the form of suckers 2
   Body rounded, or usually so; body covered with a chitinous cuticle 3
2. Body elongate, usually segmented; no digestive apparatus present.....CESTODA
   Body usually not elongate, not segmented; a digestive system always present..... TREMATODA
3. With a protrusible, spine covered proboscis; digestive apparatus always absent ..... ACANTHOCEPHALA
   No proboscis present; a well defined, simple digestive system always present..... NEMATODA

Trematoda

Key to Families of Trematoda

1. Sexes separate, blood flukes .....SCHISTOSOMIDAE
   Hermaphroditic forms 2
2. Body divided into a fore body and a hind body, the organs of attachment on the fore body and the sex organs in the hind body .....STRIGEIDAE
   Body not divided into two parts..... 3

3. Accessory organs of attachment present, structure strigeid-like ..... CYATHOCOTYLIDAE
   Organs of attachment consisting of one or two suckers 4
4. Only an oral sucker present, sometimes rudimentary 5
   Two suckers present 7
5. Oral sucker but weakly developed, intestines continuous at posterior end .....
   ..... CYCLOCOELIDAE
   Oral sucker well developed, intestines end blindly 6
6. A pharynx present, parasitic in kidney ..... EUCOTYLIDAE
   Pharynx absent, with or without ventral glands ..... NOTOCOTYLIDAE
7. With acetabulum at posterior end of body ..... PARAMPHISTOMIDAE
   Acetabulum on ventral surface, usually near center of body 8
8. With a collar of spines around the oral sucker ..... ECHINOSTOMIDAE
   Without a collar of spines 9
9. Genital pore at posterior end of body ..... BRACHYLAEMIDAE
   Genital pore more anterior 10
10. With more than two testes ..... ORCHIPEDIDAE
    Only two testes present 11
11. Ventral sucker modified into a genital sucker or gonotyl, the genital pore opening through the sucker ..... HETEROPHYIDAE
    Ventral sucker and genital pore opening separately 12
12. Small forms, genital pore near acetabulum ..... MICROPHALLIDAE
    Genital pore not near acetabulum 13
13. Small forms, receptaculum seminis absent, vitellaria lie dorsal in region of acetabulum ..... ACANTHOSTOMIDAE
    Larger, more elongate forms, vitellaria lying for the most part, lateral to the intestines 14
14. A well defined cirrus pouch present 15
    No cirrus pouch present ..... OPISTHORCHIIDAE
15. Uterus lying for the most part anterior to ovary 16
    Uterus with well defined coils posterior to ovary 17
16. Vitellaria not reaching any further posterior than anterior testis, vagina and cirrus often very long, extending posterior to acetabulum (not so in *Cloacitrema*) ..... PHILOPHTHALMIDAE
    Vitellaria overlapping intestine and extending to posterior end, vagina and cirrus not extending noticeably beyond acetabulum ..... PSILOSTOMIDAE
17. With genital pore dorsal or anterior to oral sucker ..... CEPHALOGONIMIDAE
    With genital pore at level of, or posterior to oral sucker ..... PLAGIORCHIIDAE

Family PLAGIORCHIIDAE Lühe. 1901

Key to Genera of Plagiorchiidae

1. Testes one in front of the other or slightly tandem; genital pore in front of acetabulum ..... *Plagiorchis*
   Testes at same level, genital pore at anterior tip of body 2
2. Male and female openings close together ..... *Prosthogonimus*
   Male and female openings some distance apart ..... *Schistogonimus*

Genus *Plagiorchis* Lühe, 1899

1. *Plagiorchis potanini* Skrjabin, 1928.
   Host: *Anas boschas.*
   Distribution: Transbaikalie (Siberia).
   Reference: 98.

Genus *Prosthogonimus* Lühe, 1899.

1. *Prosthogonimus anatinus* Markow, 1902.
   Hosts: *Anas boschas domesticus, Anas rubripes.*
   Distribution: Europe, North America.
   Reference: 30, 58.
2. *Prosthogonimus cuneatus* (Rudolphi, 1809).

Synonyms: *Distoma cuneatus* Rudolphi, 1809; *Prymnopryon cuneatus* (Rudolphi, 1809) Loos, 1899.

Hosts: *Cygnus cygnus, Fulica atra, Nettion crecca, Nyroca clangus, Gallus gallus, Agelaius phoeniceus phoeniceus,* and *Quiscalus quiscula aeneus.*
Distribution: Europe, Northern Asia, and North America.
Reference: 8, 10, 58.

3. *Prosthogonimus horiuchii* Morishita and Tsuchimochi, 1927.
Hosts: Domestic ducks and domestic geese.
Distribution: Formosa.
Reference: 58.

4. *Prosthogonimus japonicus* Braun, 1901.
Hosts: Chicken and *Anas boschas.*
Distribution: Japan and the Orient.
Reference: 8, 58, 90.

5. *Prosthogonimus leei* Hsü, 1935.
Host: Duck.
Distribution: China.
Reference: 34.

6. *Prosthogonimus macrorchis* Macy, 1934.
Hosts: *Anas platyrhynchos, Anas* p. (domestic). *Gallus gallus, Passer domesticus, Corvus brachyrhynchos, Phasianus colchicus torquatus,* and *Anas rubripes.*
Distribution: North America (Minnesota, Wisconsin, Michigan)
Reference: 30, 58.

7. *Prosthogonimus orientalis* Yamaguti, 1933.
Host: *Anas platyrhynchos platyrhynchos.*
Distribution: Japan.
Reference: 134.

8. *Prosthogonimus ovatus* (Rudolphi, 1803).
Synonyms: *Fasciola ovata* Rudolphi, 1803; *Distoma ovatum* (Rudolphi, 1803) Rudolphi, 1809; *Cephalogonimus ovatus* (Rudolphi, 1803) Stossich, 1892; *Prymnopryon ovatus* (Rudolphi, 1803) Looss, 1899.
Hosts: *Anas clypeata, A. ferina, A. glacialis, A. marila, A. musica, Nyroca hyemalis,* and some 40 other species of birds.
Distribution: Europe, Northern Asia, South America.
Reference: 8, 10, 58.

9. *Prosthogonimus pellucidus* (Linstow, 1873).
Synonyms: *Distoma pellucidum* Linstow, 1873; *Cephalogonimus pellucidus* (Linstow, 1873) Railliet, 1890; *Mesogonimus pellucidus* (Linstow, 1873) Neumann, 1892; *Prymnopryon pellucidus* (Linstow, 1873) Looss, 1899; *Prostogonimus pellucidus* (Linstow, 1873) Braun, 1901.
Hosts: *Gallus domesticus, Anas boschas domesticus, Numenius arquatus.*
Distribution: Europe.
Reference: 8, 10, 58.

10. *Prosthogonimus querquedulae* Yamaguti, 1933.
Host: *Querquedula querquedula.*
Distribution: Japan.
Reference: 134.

11. *Prosthogonimus rudolphii* Skrjabin, 1919.
Hosts: *Anas boschas domesticus, A. p. platyrhynchos, A. rubripes, Nyroca affinis, Nyroca collaris, Glaucionetta clangula americana,* and *Mergus serrator.*
Distribution: Europe, North America.
Reference: 30, 58.

12. *Prosthogonimus skrjabini* Zakharow, 1920.
Hosts: Domestic duck and "quack" duck.
Distribution: Russia.
Reference: 58.

Genus *Schistogonimus* Lühe, 1909.

1. *Schistogonimus rarus* (Braun, 1901).
   Synonym: *Prostogonimus rarus* Braun, 1901.
   Hosts: *Anas boschas, Fulica atra.*
   Distribution: Europe.
   Reference: 8, 52, 58.

Family CEPHALOGONIMIDAE Nicoll, 1915

Genus *Cephalogonimus* Poirier, 1886

1. *Cephalogonimus* sp.
   Host: Duck.
   Distribution: North America.
   Reference: 1.

Family OPISTHORCHIIDAE Braun, 1901

Key to Genera of Opisthorchiidae

1. Uterine coils extending anterior to acetabulum ..... *Metorchis*
   Uterine coils not extending anterior to acetabulum 2
2. Vitellaria divided on either side into an antovaral and postovaral portion, the postovaral portion extending to near the posterior end ..... *Amphimerus*
   Vitellaria not divided, not extending posterior to ovary ..... *Ophisthorchis*

Genus *Opisthorchis* Blanchard, 1895

1. *Opisthorchis geminus* (Loos, 1896).
   Synonyms: *Distoma geminus* Looss, 1896; *Distoma geminus* (Looss, 1896). Kowalewski, 1898.
   Hosts: *Milvus parasiticus, Anas boschas fera, Circus aeruginosus.*
   Distribution: Europe, Egypt.
   Reference: 51, 52, 68.
2. *Opisthorchis simulans* (Looss, 1896).
   Synonyms: *Distomum simulans* Looss, 1896; *Opisthorchis simulans* var. *poturzycensis* Kowalewski, 1898.
   Hosts: *Anas penelope, Fulix cristata, Circus aeruginosus, Pernis spivorus, Anas platyrhynchos.*
   Distribution: Europe, Egypt.
   Reference: 51, 52, 68.

Genus *Amphimerus* Barker, 1911

1. *Amphimerus anatis* (Yamaguti, 1933).
   Synonym: *Opisthorchis anatis* Yamaguti, 1933.
   Hosts: *Gallus gallus, Anas platyrhynchos platyrhynchos,* and domestic ducks.
   Distribution: Japan and China.
   Reference: 134.
2. *Amphimerus elongatus* Gower, 1938.
   Hosts: *Glaucionetta changula americana, Anas p. platyrhynchos, A. platyrhynchos* (domestic), *A. rubripes, Nyroca affinis, N. valisineria, N. americana, Mareca americana, Paecilionetta bahamensis rubrirostris.*
   Distribution: North America (Michigan).
   Reference: 30.

Genus *Metorchis* Looss, 1899

1. *Metorchis coeruleus* (Braun, 1902).
   Host: *Cairina moschata.*
   Distribution: Brazil.
   Reference: 10, 33.
2. *Metorchis crassiusculus* (Rudolphi, 1809).
   Synonyms: *Planaria bilis* Braun, 1790; *Distoma crassiusculum* Rudolphi, 1809;

Opisthorchis crassiuscula (Rudolphi, 1809) Kowalewski, 1898; *Opisthorchis xanthosomus* var. *compactus* Kowalewski, 1898; *Metorchis crassiusculus* (Rudolphi, 1809) Looss, 1899.

Hosts: *Mergus serrator*, *Anas querquedula*.
Distribution: Europe.
Reference: 33.

3. *Metorchis intermedius* Hinemann, 1937.
Host: Ducks.
Location: Germany.
Reference: 33.

4. *Metorchis orientalis* Tanabe, 1921.
Hosts: Ducks, grebes and *Milvus lineatus*.
Distribution: Japan.
Reference: 33, 35.

5. *Metorchis tiawanensis*.
Host: Ducks.
Locality: Asia.
Reference: 35.

6. *Metorchis tener* Kowalewski, 1903.
Host: *Mergus merganser*.
Distribution: Europe.
Reference: 33.

7. *Metorchis xanthosomus* (Creplin, 1846).
Synonyms: *Distoma xanthosomum*, Creplin, 1846; *Opisthorchis xanthosomus* (Creplin, 1846) Kowalewski, 1898; *Metorchis xanthosomus* (Creplin, 1846) Braun, 1902.
Hosts: *Oidemia nigra*, *Podiceps ruficollis*, *Mergus serrator*, *Anas platyrhynchos*, *Anas querquedula*.
Distribution: Europe.
Reference: 33.

Family HETEROPHYIDAE Odhner, 1914
Genus *Tocotrema* Looss, 1899

1. *Tocotrema concavum* (Creplin, 1825).
Synonyms: *Distoma concavum* Creplin, 1835; *Distoma (Dicrocoelum) concavum* (Creplin, 1825) Stossich, 1892; *Cotylogonimus (Cryptocotyle) concavum* (Creplin, 1825) Luhe, 1899; *Tocotrema concavum* (Creplin, 1825) Looss, 1899; *Cryptocotyle concavum* (Creplin, 1825) Fischoeder, 1903.
Hosts: *Urinator stellatus*, *Colymbus cristatus*, *Colymba nigricollis Mergus merganser*, *Mergus serrata*, *Anas hornschuchii*, *Nyroca marila*, *Nyroca clangula*, *Oidemia fusca*, *Alco torda*, *Colymbus rufigularis*, *Herelda glacialis*, *Larus glacus*, *Phalacrocorax graculus*.
Distribution: Europe.
Reference: 88.

Family MICROPHALLIDAE Travassos, 1920
Key to Genera of Microphallidae

1. With a distinct cirrus pouch present ..... *Maritrema*
Without a distinct cirrus pouch 2
2. With a narrow papillae in genital atrium ..... *Levinseniella*
Papillae more or less cone-shaped 3
3. Vagina opening near base of papillae ..... *Spelotrema*
Vagina opening near mouth of genital atrium ..... *Spelophallus*

Genus *Spelophallus* Jägerskiöld, 1908

1. *Spelophallus bucephalae* Yamaguti, 1935.
Host: *Bucephala clangula*.
Distribution: Japan.
Reference: 136.

2. *Spelophallus primus* Jägerskiöld, 1908.

Hosts: *Somateria mollissima, Haemetopus ostraligus.*
Distribution: Europe.
Reference: 38.

Genus *Spelotrema* Jägerskiöld, 1901

1. *Spelotrema pygmaeum* (Levinsen, 1881).
Synonyms: *Distoma pygmaea* Levinsen, 1881; *Levinsenia pygmaea* (Levinsen, 1881) Stossich, 1899; *Levinseniella pygmaea* (Levinsen, 1881) Stafford, 1903.
Hosts: *Somateria mollissima, Oidemia nigra, Glaucionetta clangula americana.*
Distribution: Europe and North America.
Reference: 37.

Genus *Levinseniella* Stiles and Hassall, 1901

1. *Levinseniella brachysoma* (Creplin, 1837).
Synonyms: *Distoma brachysoma* Creplin, 1837; *Levinsenia brachysoma* (Creplin, 1837) Stossich, 1899.
Hosts: *Clangula hyemalis, Oidemia nigra, Bucephala clangula* and a number of other water birds.
Distribution: Europe.
Reference: 37.
2. *Levinseniella cruzi* Travassos, 1920.
Host: *Poecilonetta bahamensis.*
Distribution: Brazil.
Reference: 128.
3. *Levinseniella minuta* Price, 1934.
Host: *Nyroca affinis.*
Distribution: West Indies.
Reference: 83.
4. *Levinseniella pellucida* Jägerskiöld, 1907.
Hosts: *Anas platyrhynchos, Nyroca fuligula.*
Distribution: Europe.
Reference: 38.

Genus *Maritrema* Nicoll, 1907

1. *Maritrema acadiae* (Swales, 1933)
Synonym: *Streptovitella acadiae* Swales, 1933.
Host: *Anas rubripes.*
Distribution: North America.
Reference: 109.
2. *Maritrema nettae* Gower, 1938.*
Hosts: *Nyroca affinis, Glaucionetta clangula americana.*
Distribution: North America (Michigan).
Reference: 30.
3. *Maritrema nicolli* Travassos, 1920.
Host: *Poecilonetta bahamensis.*
Distribution: Brazil.
Reference: 128.
4. *Maritrema rhodanicum.*
Host: Ducks.
Location: France.
Reference: 13.

Family ORCHIPEDIDAE Skrjabin, 1924

1. *Orchipedum tracheicola* (Braun, 1901).
Hosts: *Oidemia fusca, Oidemia fusca deglandi.*

* Rankin (Am. Midl. Nat. **22**(2):438-451) has designated *Maritrema nettae* as type for his new genus *Maritreminoides.* The new genus is distinguished from the old by the lateral anterior extensions of the uterus and the long, protrusible cirrus.

Distribution: Europe, North America.
Reference: 9, 10, 14.

Family PHILOPHTHALMIDAE Looss, 1899

Key to Genera of Philophthalmidae

1. Cirrus pouch very long, extending posterior to acetabulum; in eye of host..... *Philophthalmus*
Cirrus pouch not reaching posterior to acetabulum; in cloaca.....*Cloacitrema*

Genus *Philophthalmus* Looss, 1899

1. *Philophthalmus anatinus* Sugimoto, 1928.
Host: Domestic duck.
Distribution: Formosa.
Reference: 100.
2. *Philophthalmus nycrocae* Yamaguti, 1934.
Host: *Nyroca ferina ferina.*
Distribution: Japan.
Reference: 135.
3. *Philophthalmus razalensis* Tabangui, 1928.
Host: Domestic duck.
Distribution: Philippine Islands.
Reference: 120.

Genus *Cloacitrema* Yamaguti, 1935

1. *Cloacitrema ovatum* Yamaguti, 1935.
Host: *Bucephala clangula changula.*
Distribution: Japan.
Reference: 136.

Family ACANTHOSTOMIDAE Poche, 1925

Genus *Gymnophallus* Odhner, 1900

1. *Gymnophallus affinis* Jameson and Nicoll, 1913.
Host: *Oidemia nigra.*
Distribution: Europe.
Reference: 36.
2. *Gymnophallus bursicola* Odhner, 1900.
Synonym: *Levcithodendrium somateriae* (Levinsen, 1881) Jameson, 1902 (in part).
Hosts: *Somateria mollissima* and *Melanitta fusca.*
Distribution: Europe.
Reference: 76.
3. *Gymnophallus choledocus* Odhner, 1900.
Hosts: *Somateria mollissima, Tadorna tadorna.*
Distribution: Europe.
Reference: 76.
4. *Gymnophallus dipsilis* Nicoll, 1907.
Hosts: *Oidemia fusca, O. nigra.*
Distribution: Europe.
Reference: 36.
6. *Gymnophallus oidemiae* Jameson and Nicoll, 1913.
Synonym: *Levcithodendrium somateriae* (Levinsen, 1881) Jameson, 1902 (in part).
Host: *Oidemia nigra.*
Distribution: Europe.
Reference: 36.
7. *Gymnophallus ovoplenus* Jameson and Nicoll, 1913.
Host: *Oidemia nigra.*
Distribution: Europe.
Reference: 36.
8. *Gymnophallus somateriae* (Levinsen, 1881).
Synonyms: *Distoma somateriae* Levinsen, 1881; *Levcithodendrium somateriae* (Lev-

insen, 1881) Stossich, 1899; *Levcithodendrium somateriae* (Levinsen, 1881) Jameson, 1902.
Host: *Somateria mollissima.*
Distribution: Europe.
Reference: 73, 76.

Family Cyclocoelidae Kossack, 1911

Key to Genera of Cyclocoelidae

1. Intestines bearing diverticula on the inner side; body oval in shape, equally rounded at both ends.....*Typhlocoelum*
Intestines without diverticula, body tapering more toward the anterior end..... 2
2. Sex glands forming a triangle in the posterior loop of the intestine.....*Cyclocoelum*
Sex glands lie in a straight line in the longitudinal body axis, the ovary between the two testes .....*Ophthalmophagus*

Genus *Cyclocoelum* Brandes, 1892

1. *Cyclocoelum arcuatum* Stossich, 1902.
Synonyms: *Hyptiasmus arcuatus* (Stossich, 1902) Kossack, 1911; *Hyptiasmus laevigatus* Kossack, 1911; *Hyptiasmus tumidus* Kossack, 1911; *Hyptiasmus oculeus*, Kossack, 1911; *Hyptiasmus magnus* Johnson, 1911; *Hyptiasmus coelonotus* Witenberg, 1926; *Transcoelum oculeum* (Kossack, 1911) Witenberg, 1926; *Transcoelum sigillum* Witenberg, 1926.
Hosts: *Oidemia fusca, O. nigra, Nyroca fuligula, N. ferina, Somateria mollissima, Bucephala clangula, Mergus albellus, Clangula hyemalis.*
Distribution: Europe, Japan.
Reference: 41, 43, 105.
2. *Cyclocoelum pseudomacrostomum* Harrah, 1922.
Hosts: Wild ducks, *Fulica americana.*
Distribution: United States (Nebraska and Michigan).
Reference: 32.

Genus *Ophthalmophagus* Stossich, 1902

Synonyms: *Hyptiasmus* Kossack, 1911; *Spanometra* Kossack, 1911; *Transcoelum* Witenberg, 1926.
1. *Ophthalmophagus magalhaesi* Travassos, 1921.
Host: *Cairina moschata* dom.
Distribution: Brazil.
Reference: 128.
2. *Opthalmophagus massinoi* Witenberg, 1926.
Synonyms: *Hyptiasmus massinoi* (Witenberg, 1926) Joyeaux and Baer, 1927.
Host: Wild duck.
Distribution: Russia.
Reference: 129.
3. *Ophthalmophagus robustus* (Stossich, 1902).
Synonyms: *Cyclocoelum robustum* Stossich, 1902; *Monostomum robustum* (Stossich, 1902), Lühe, 1909; *Hyptiasmus robustus* (Stossich, 1902) Witenberg, 1926.
Host: *Nyroca fuligula.*
Distribution: Europe.
Reference: 41, 43.
4. *Ophthalmophagus theodori* (Witenberg, 1928).
Synonym: *Hyptiasmus theodori* Witenberg.
Host: *Dafila acuta.*
Distribution: Palestine.
Reference: 129.

Genus *Typhlocoelum* Stossich, 1902

1. *Typhlocoelum cucumerinum* (Rudolphi, 1809).
Synonyms: *Monostomum flavum* Mehlis, 1831; *Monostomum sarcidioricola* Megnin,

1890; *Monostomum cucumerinum* Rudolphi, 1809; *Typhlocoelum flavum* (Mehlis, 1831) Stossich, 1902; *Typhlocoelum obovale* Neumann, 1909; *Typhlocoelum reticuliare* Johnson, 1913; *Typhlutimum sarcidiornicola* (Megnin, 1890) Witenberg, 1926; *Typhlocoelum americana* Manter and Williams, 1931.

Hosts: *Anas platyrhynchos, Oidemia fusca, Nyroca fuligula, Nyroca marila, Somateria mollissima, Clangula hyemalis, Mergus albellus, Mergus serrator, Anas rubripes, Nyroca americana.*

Distribution: North America, South America, Europe, Africa.

Reference: 30, 41, 43, 59.

2. *Typhlocoelum cymbium* (Diesing, 1850).

Synonyms: *Monostomum cymbium* Diesing, 1850; *Haematotrephus cymbius* (Diesing, 1850) Stossich, 1902; *Typhlocoelum cymbium* (Diesing, 1850) Kossack, 1911; *Tracheophilus sisowi* Skrjabin, 1913.

Hosts: *Anas platyrhynchos, Nyroca affinis, Spatula clypeata, Anas rubripes, Podilymbus podiceps, Dafila acuta,* and shore birds.

Distribution: North America, South America, Japan, Europe.

Reference: 30, 90, 107.

3. *Typhlocoelum neivai* Travassos, 1921.

Host: "Anatidae."

Distribution: Brazil.

Reference: 128.

Family Eucotylidae Skrjabin, 1924

Genus *Eucotyle* Cohn, 1904

1. *Eucotyle wehri* Price, 1930.

Host: *Querquedula discors.*

Distribution: United States (Montana).

Reference: 82.

2. *Eucotyle zakharowi* Skrjabin, 1924.

Hosts: *Nyroca fuligula, Fuligula cristata.*

Distribution: Europe (Don Region of Russia).

Reference: 97.

Family Echinostomidae Dietz, 1909

Key to Genera of Echinostomidae

1. Head spines in a double row 2
   Head spines in a single row 4
2. Vitellaria reaching to or anterior to acetabulum ..... *Hypoderaeum*
   Vitellaria barely reaching acetabulum 3
3. Medium to large forms, uterus relatively long ..... *Echinostoma*
   Small to medium-sized forms, uterus short, eggs large ..... *Echinoparyphium*
4. Cirrus pouch short, not reaching posterior to acetabulum 5
   Cirrus pouch long, reaching posterior to acetabulum ..... Acanthoparyphium
5. Vitellaria not reaching anterior to ovary ..... *Stephanoprora*
   Vitellaria reaching anterior to ovary 6
6. Elongate forms, sex organs near posterior end ..... *Himasthala*
   Small forms, vitellaria extending to posterior border of acetabulum; sex glands midway from acetabulum to posterior end ..... *Echinochasmus*

Genus *Echinostoma* Dietz, 1909

1. *Echinostoma elongatum* Hsü, 1935.

Hosts: Ducks and domestic ducks.

Distribution: China.

Reference: 34.

2. *Echinostoma minor* Hsü, 1935.

Hosts: Ducks and domestic ducks.

Distribution: China.

Reference: 34.

3. *Echinostoma pekinensis* Ku, 1937.
Host: *Anas domesticus* var. *pekinensis*.
Distribution: China.
Reference: 46.

4. *Echinostomum revolutum* (Froelich, 1802).
Synonyms: *Distomum echinatum* Zeder, 1803; *Echinostoma miyagawai* Ishii, 1932; *Echinostoma cinetorchis* Ando and Ozaki, 1923; *Echinostoma armigerum*, Barker and Irving, 1915; *Echinostoma coalitum* Barker and Beaver, 1915; *E. mendax* Dietz, 1909, *Echinoparyphium paraulum* (Dietz, 1910) Sprehn, 1929; *Echinostoma columbae* Zunker, 1925; *Echinostoma limicoli* Johnson, 1920.

Hosts: *Anas brasiliense*, *A. platyrhynchos* (domestic), *A. p. platyrhynchos*, *A. superciliosa*, *Cairina moschata*, *Mareca americana*, *Nyroca fuligula*, *Nyroca marila*, *Oidemia nigra*, *Tadorna tadorna*, *Nettion carolinense*, *Querquedula discors*, *Anas rubripes*.
Distribution: Cosmopolitan.
Reference: 6.

Genus *Echinoparyphium* Dietz, 1909

1. *Echinoparyphium baculus* (Diesing, 1850).
Synonyms: *Distoma mergi* Rudolphi, 1819; *Distoma baculus* Diesing, 1850; *Echinostoma baculus* (Diesing, 1850) Cobbold, 1860; *Echinoparyphium baculus* (Diesing, 1850) Luhe, 1909.

Hosts: *Mergus albellus*, *Nyroca marila*, *Bucephala clangula Spatula clypeata*, *Oidemia fusca*, *Colymbus arcticus*.
Distribution: Europe.
Reference: 20.

2. *Echinoparyphium flexum* (Linton, 1892).
Host: Ducks.
Distribution: North America.
Reference: 48, 62.

3. *Echinoparyphium recurvatum* (v. Linstow, 1873).
Hosts: *Anas platyrhynchos*, *Nyroca marila*, *Nyroca fuligula*, chickens and grebes
Distribution: Europe, Japan.
Reference: 20.

Genus *Himasthala* Dietz, 1909

1. *Himasthala incisa* Linton, 1928.
Host: *Oidemia deglandi*.
Distribution: North America (Woods Hole).

Genus *Echinoschamus* Odhner, 1910

1. *Echinoschamus* sp. (Odhner, 1910).
Synonym: *Heteroechinostomum* sp. Odhner, 1910.
Host: *Mergus serrator*.
Distribution: Europe.
Reference: 100.

Genus *Acanthoparyphium* Dietz, 1909

1. *Acanthoparyphium marilae* Yamaguti, 1934.
Host: *Nyroca marila*.
Distribution: Japan.
Reference: 135.

Genus *Stephanoprora* Odhner, 1902

1. *Stephanoprora mergi* Cannon, 1938.
Host: *Mergus americanus*.

Distribution: North America.
Reference: 12.

2. *Stephanoprora spinosa* (Odhner, 1910).
Synonyms: *Monilifer spinulosus* Dietz, 1909 nec. Rudolphi, 1809.
Hosts: *Gloucionetta clangula americana* and a number of European grebes.
Distribution: North America and Europe.
Reference: 20, 30.

Genus *Hypoderaeum* Dietz, 1909

1. *Hypoderaeum conoideum* (Bloch, 1782).
Synonyms: *Cacullanus conoidens* Bloch, 1782; *Echinostoma conoideum* (Block, 1782) Kowalewski, 1897; *Hypoderaeum conoideum* (Block 1782) Dietz, 1909.
Hosts: *Anas platyrhynchos, Anas querquedula, Nyroca marila, Spatula clypeata, Mergus merganser* and also from chickens, grebes, and geese.
Distribution: Europe, North America.
Reference: 20, 100.

2. *Hypoderaeum sinensis* Hsü, 1935.
Hosts: Ducks and domestic ducks.
Distribution: China.
Reference: 34.

Family PSILOSTOMIDAE Odhner, 1913.

Key to Genera of Psilostomidae

1. Body elongate, narrow 2
Body conical, rounded 3
2. Testes oval, entire, posterior end rounded ..... *Psilostoma*
Testes elongate, more or less notched, posterior end pointed ..... *Psilochasmus*
3. Acetabulum in second body fourth ..... *Psilotrema*
Acetabulum near center of body ..... *Sphaeridiotrema*

Genus *Psilostomum* Looss, 1899*

1. *Psilostomum brevicolle* (Creplin, 1829).
Synonyms: *Distoma brevicolle* Creplin, 1829; *Distoma platyurum* Mühling, 1896; *Psilostomum platyurum* (Mühling, 1896) Looss, 1899; *Psilostomum brevicolle* (Creplin, 1829) Braun, 1902.
Hosts: *Haematopus ostralegus, Oidemia nigra, Clangula hyemalis.*
Distribution: Europe.
Reference: 10, 78.

Genus *Psilochomus* Luhe, 1909

1. *Psilochamus agilis* Travassos, 1921.
Host: *Poecilonetta bahamensis.*
Distribution: Brazil.
Refereence: 128.

2. *Psilochamus lecithosus* Otte, 1926.
Host: *Anas platyrhynchos.*
Distribution: Europe (Lettland).
Reference: 100.
Reference: 100.

3. *Psilochamus oxyurus* (Creplin, 1825).
Synonyms: *Distoma oxyurus* Creplin, 1825; *Psilostomum oxyurum* (Creplin, 1825) Braun, 1902; *Psilochamus oxyurus* (Creplin, 1825) Lühe, 1909; *Psilochamus longicirratus* Skrjabin, 1913.
Hosts: *Nyroca marila, Nyroca fuligula, Oidemia nigra, Tadorna tadorna, Bucephala changula hyemalis, Anas platyrhynchos* (domestic).
Distribution: Europe.
Reference: 108.

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* Beaver (Jour. Parasitol. **25**(5):383-393) reports artificial infection of ducks with *Psilostomum ondatrae* Price, 1931.

Genus *Psilotrema* Odhner, 1913

1. *Psilotrema simillimum* (Mühling, 1898).
   Synonyms: *Distoma simillimum* Mühling, 1898; *Psilotomum simillimum* (Mühling, 1898) Looss, 1899; *Psilotrema simillimum* (Mühling, 1898) Odhner, 1913.
   Host: *Nyroca nyroca.*
   Distribution: Europe.
   Reference: 71.
2. *Psilotrema spiculigerum* (Mühling, 1896).
   Synonyms: *Distoma spiculigerum* Mühling, 1898; *Psilostomum spiculigerum* (Mühling, 1898) Looss, 1899; *Psilotremt spiculigerum* (Mühling, 1898) Odhner, 1913.
   Host: *Nyroca nyroca.*
   Distribution: Europe.
   Reference: 70, 71.

Genus *Sphaeridiotrema* Odhner, 1913

1. *Sphaeridiotrema globulus* (Rudolphi, 1814)
   Synonyms: *Distoma globulus* Rudolphi, 1814; *Sphaeridiotrema globulus* (Rudolphi, 1814) Odhner, 1913.
   Hosts: *Marila affinis, Dafila acuta, Nyroca marila, Nyroca fuligula, Clangula hyemalis, Mergus merganser, Mergus serrator, Alco torda* and *Cygnus olor.*
   Distribution: Europe, Asia, and North America.
   Reference: 84, 117.

Family Brachylaemidae

Genus *Leucochloridiomorpha* Gower, 1938

1. *Leucochloridiomorpha macrocotyle* Gower, 1938.
   Host: *Anas rubripes.*
   Distribution: North America (Michigan).
   Reference: 30.

Family Schistosomidae Looss, 1899

Key to Genera of Schistosomidae

1. Females slender, males longer than females, and somewhat flattened to form gynaecophoric canal, which extends anterior to acetabulum ..... *Microbilharzia*
   Females similar in shape to males; males without a well defined gynaecophoric canal 2
2. Body cylindrical, or nearly so 3
   Body flattened or partially so 4
3. Female unknown; posterior end of body thread-like, middle portion wider than either end; suckers present ..... *Trichobilharzia*
   Male and female long and slender; gynaecophoric canal reduced to a short groove in anterior part of body; one sucker present, or entirely absent ..... *Gigantobilharzia*
4. Suckers absent, common caecum with lateral dendritic branches ..... *Dendritobilharzia*
   Suckers present, caecum without branches 5
5. Body composed of a narrow anterior portion and a broader posterior one.. *Bilharziella*
   Body composed of a broader anterior portion and a long narrow posterior one ..... *Pseudobilharziella*

Genus *Microbilharzia* Price, 1929

1. *Microbilharzia chapini* Price, 1929.
   Synonym: *Ornithobilharzia* sp. Chapin, 1924.
   Host: *Nyroca affinis.*
   Distribution: North America (Maryland).
   Reference: 81.

Genus *Bilharziella* Looss, 1899

1. *Bilharziella polonica* (Kowalewski, 1895).
Synonyms: *Bilharzia polonica* Kowalewski, 1895; *Schistosomum polonicum* (Kowalewski, 1895) Railliet, 1898; *Ornithobilharzia polonica* (Kowalewski, 1895) Tanabe, 1925.
Hosts: *Anas platyrhynchos, Anas platyrhynchos* (domestic), *Querquedula querquedula, Nettion crecca, Dafila acuta, Fuligula fuligula, Ardea cinerea, Nyroca leucophthalma* and *Cygnus olor.*
Distribution: Europe, North America.
Reference: 81, 115.

Genus *Pseudobilharziella* Ejsmont, 1929

1. *Pseudobilharziella querquedulae* McLeod, 1937.
Host: *Querquedula discors.*
Distribution: Manitoba, Canada.
Reference: 63.
2. *Pseudobilharziella yokogawai,* (Oiso, 1927).
Synonym: *Bilharziella yokogawai,* Oiso, 1927.
Host: *Anas platyrhynchos domestica.*
Distribution: Formosa.
Reference: 21, 63.

Genus *Dendritobilharzia* Skrjabin and Zakharow, 1920.

1. *Dendritobilharzia pulverulenta* (Braun, 1901).
Synonyms: *Bilharziella pulverulenta* Braun, 1901; *Dendritobilharzia odhneri* Skrjabin, and Zakharow, 1920.
Hosts: *Querquedula querquedula, Anas platyrhynchos.*
Distribution: Africa, Europe.
Reference: 10, 81.

Genus *Trichobilharzia* Skrjabin and Zakharow, 1920

1. *Trichobilharzia ocellata* (La Vallette, 1854).
Synonym: *Trichobilharzia kossarewi* Skrjabin and Zakharow, 1920.
Host: *Querquedula discors,* ducks.
Distribution: Europe (Russia).
Reference: 11, 81.

Genus *Gigantobilharzia* Odhner, 1910

1. *Gigantobilharzia monocotylea* Szidat, 1930.
Hosts: *Anas platyrhynchos, Larus ridibundus.*
Distribution: Europe.
Reference: 116.

Family Cyathocotylidae Poche, 1925

Genus *Cyathocotyle* Mühling, 1896

1. *Cyathocotyle melanittae* Yamaguti, 1934.
Host: *Melanitta fusca.*
Distribution: Japan.
Reference: 135.
2. *Cyathocotyle prussica* Mühling, 1896.
Host: *Clangula hyemalis.*
Distribution: Europe (Germany)
Reference: 70.

Family Strigeidae Railliet, 1919

Key to Genera of Strigeidae

1. Fore body somewhat flattened 2
Fore body cup-shaped 3

2. Division between fore body and hind body distinct ..... *Neodiplostomum*
   Division between fore body and hind body not distinct ..... *Paradiplostomum*
3. Vitellaria extending into anterior body, two appendages on fore body..... *Parastrigea*
   Vitellaria confined to hind body 4
4. Bursa copulatorix with a muscular, sucker-like ring ..... *Cotylurus*
   Bursa copulatorix a simple sac ..... *Apatemon*

Genus *Apatemon* Szidat, 1928

1. *Apatemon fuligulae* Yamaguti, 1933.
   Hosts: *Fuligula fuligula, Melanitta fusca steinegeri, Anas domestica.*
   Distribution: Japan.
   Reference: 134.
2. *Apatemon gracilis* (Rudolphi, 1819).
   Synonyms: *Amphistoma gracile* Rudolphi, 1819; *Holostomum gracile* (Rudolphi, 1819) Dujardin, 1845; *Strigea gracilis* (Rudolphi, 1819) Luhe, 1909; *Apatemon gracilis* (Rudolphi, 1819) Szidat, 1928.
   Hosts: *Mergus merganser, Mergus albellus, Mergus serrator, Anas fusca, A. clangula, A. nigra, Anser albifrons, Anas boschas ferox, Heralda glacialis, Nyroca ferina, Nyroca clangula.*
   Distribution: Europe.
   Reference: 114.
3. *Apatemon graciliformis* Szidat, 1928.
   Host: *Anas moschata.*
   Distribution: Brazil.
   Reference: 114.
4. *Apatemon minor Yamaguti*, 1933.
   Hosts: *Anas platyrhynchos, Nettion formosum.*
   Distribution: Japan.
   Reference: 134.
5. *Apatemon pellucidus* Yamaguti, 1933.
   Host: Domestic duck (experimental).
   Distribution: Japan.
   Reference: 134.
6. *Apatemon sphaerocephalus* (Brandes, 1888).
   Synonyms: *Holostomum sphaerocephalum* Diesing, 1850; *Amphistoma sphaerocephalus* Westrumb, 1923; *Holostomum sphaerocephalus* Diesing, 1893.
   Host: *Anas moschata.*
   Distribution: Brazil.
   Reference: 114.

Genus *Cotylurus* Szidat, 1928

1. *Cotylurus cornutus* (Rudolphi, 1809).
   Synonyms: *Amphistoma cornutum* Rudolphi, 1809; *Holostomum cornutum* (Rudolphi, 1809) Dujardin, 1845; *Holostomum multilobum* Cobbold, 1860; *Holostomum errariсum* Ercolani, 1881; *Strigea tarda* Steenstrup, 1842; *Cotylurus cornutus* (Rudolphi, 1809) Szidat, 1928.
   Hosts: *Chadrius pluvialis, Numerius arquaticus, Anas boschas ferox, Anas boschas domestica, Nyroca marila.*
   Distribution: Europe.
   Reference: 114.
2. *Coytlurus erraticum* (Rudolphi, 1809).
   Synonyms: *Amphistoma erraticum* Rudolphi, 1809; *Amphistoma gracile* Bellingham, 1844; *Strigea erratica* (Rudolphi, 1809 nec. Brandes, 1888) Luhe, 1909; *Holostomum erraticum* (Rudolphi, 1809) Dunjardin 1848; *Cotylurus erraticus* (Rudolphi, 1809) Szidat, 1928.
   Hosts: *Colymbus arcticus, Colymbus septentrionalis, Mergus albellus.*
   Distribution: Europe.
   Reference: 114.

3. *Cotylurus flabelliformis* (Faust, 1917).
Hosts: *Anas platyrhynchos, A. rubripes, Mareca americana, Querquedula discors, Nettion carolinense, Spatula clypeata, Gualcionetta clangula americana, Nyroca affinis, N. marila, N. collaris, N. americana, N. valisenira.*
Distribution: North America.
Reference: 125.

Genus *Paradiplostomum* La Rue, 1926

1. *Paradiplostomum ptychocheilus* (Faust, 1917).
Hosts: *Mergus americanus, Mergus serrator, Lophodytes cucullatus* and *Clangula hyemalis.*
Distribution: North America.
Reference: 126.

Genus *Parastrigea* Szidat, 1927

1. *Parastrigea robusta* Szidat, 1927.
Host: *Anas boschas domestica.*
Distribution: Europe.
Reference: 114.

Genus *Neodiplostomum* Railliet, 1919

1. *Neodiplostomum orientale* (Yamaguti, 1933).
Synonyms: *Diplostomulum orientale* Yamaguti, 1934; *Proalaria mergi* Yamaguti, 1933; *Neodiplostomum orientale* Yamaguti, 1934.
Host: *Mergus merganser merganser.*
Distribution: Japan (Lake Birva).
Reference: 134.

Family NOTOCOTYLIDAE Luhe, 1909.

Key to Genera of Notocotylidae

1. One of more rows of glands on ventral surface 2
No glands present on ventral surface..... *Paramonostomum*
2. Glands distinct and protrusible, in 2 to 5 longitudinal rows ..... *Notocotylus*
Glands not distinct, not protrusible, central row forming a ridge ..... *Catatropis*

Genus *Notocotylus* Diesing, 1839

1. *Notocotylus aegypticus* (Odhner, 1905).
Synonyms: *Notocotyle aegyptica* Odhner, 1905; *Notocotylus aegypticus* Odhner, 1905) Kossack, 1911.
Host: *Anas domestica.*
Distribution: Egypt.
Reference: 43.
2. *Notocotylus anatis* Ku, 1937.
Host: *Anas domestica* var. *pekinensis.*
Distribution: China.
Reference: 45.
3. *Notocotylus attenuatus* (Rudolphi, 1809).
Synonyms: *Monostoma attenuatum* Rudolphi, 1809; *Notocotylus triserialis* Diesing, 1839; *Notocotyle triserialis* (Diesing, 1839) Diesing, 1850; *Notocotylus attenuatus* (Diesing, 1839); Kossack, 1911.
Hosts: *Mergus merganser, Anser fabalis, Anas platyrhynchos, Anas penelope, Anas crecca, Anas acuta, Clangula hyemalis, Tadorna tadorna, Spatula clypeata, Somateria mollissima, Anas querquedula, Nyroca fuligula, N. ferina, Oidemia fusca, Anas superciliosa.*
Distribution: Europe, Japan, Australia.
Reference: 43.
4. *Notocotylus gibbus* (Mehlis, 1846).

Synonyms: *Monostomum gibbum* Mehlis, 1846 (nomen mudum); *Notocotylus gibbus* (Mehlis, 1846) Kossack, 1911.
Hosts: *Fulica atra, Gallinula chlorospus, Anas platyrhynchos* (dom.)
Distribution: Europe, North America.
Reference: 43.

5. *Notocotylus imbricata* Szidat, 1935.
Hosts: *Nyroca clangula, Anas torquatus, Phynchapsis clypeata.*
Distribution: Europe.
Reference: 119.

6. *Notocotylus intestinalis* Tabangui, 1928.
Host: *Anas domestica.*
Distribution: Philippines.
Reference: 120.

7. *Notocotylus magniovatus* Yamaguti, 1934.
Hosts: *Anser albifrons, Aix galericulata.*
Distribution: Japan.
Reference: 135.

8. *Notocotylus naviformis* Tabangui, 1928.
Host: *Anas domestica.*
Distribution: Philippines.
Reference: 120.

9. *Notocotylus scineti* Fuhrmann, 1919.
Hosts: *Anas querquedula, Anas platyrhynchos.*
Distribution: Europe.
Reference: 118.

10. *Notocotylus thienemanii* Szidat and Szidat, 1933.
Hosts: *Anas crecca, Anas boschas, Gallus domestica.*
Distribution: Europe.
Reference: 118.

11. *Notocotylus urbanensis* (Cort, 1914).
Hosts: *Aix sponsa, Dafila acuta, Fiber zibethicus, Anas p. platyrhynchos.*
Distribution: North America.
Reference: 30, 32.

Genus *Catatropis* Odhner, 1905

1. *Catatropis verrucosa* (Froelich, 1789).
Synonyms: *Fasciola verrucosa*, Froelich, 1789; *Fasciola anseris* Gmelin, 1789; *Monostoma verrucosa* (Froelich, 1789) Monticelli, 1892; *Festucaria pedata* Schrank, 1786, in part; *Notocotylus triserialis* Diesing, 1839, in part; *Catatropis verrucosa* (Froelich, 1789) Odhner, 1905.
Hosts: *Anas platyrhynchos, Somateria mollisima, Mergus serrator, Bucephala clangula, Clangula hyemalis, Oidemia nigra.*
Distribution: Europe, Africa, Asia.
Reference: 52.

Genus *Paramonostomum* Luhe, 1909

1. *Paramonostomum alveatum* (Mehlis, 1846).
Synonyms: *Monostoma alveatum* Mehlis, 1846; *Monostoma verrucosum* (Froelich, 1789) Erdl, 1857; *Notocotyles alveiforme* Cohn, 1904; *Paramonostomum alveatum* (Mehlis, 1846) Luhe, 1909.
Hosts: *Oidemia fusca, Nyroca marila, Clangula hyemalis, Somateria mollissima, Anser anser, Branta bernicla, Cygnus cygnus.*
Distribution: Europe.
Reference: 43, 52.

2. *Paramonostomum bucephalae* Yamaguti, 1935.
Host: *Bucephala clangula.*
Distribution: Japan
Reference: 136.

3. *Paramonostomum parvum* Stunkard and Dunihue, 1931.
Host: Domestic duck.
Distribution: North America (New York).
Reference: 108.
4. *Paramonostomum ovatus* Hsü, 1935.
Hosts: *Anas platyrhynchos* and domestic duck.
Distribution: China.
Reference: 34.

Family PARAMPHISTOMIDAE Fischoeder, 1901

Genus *Zygocotyle* Stundard, 1916

1. *Zygocotyle lunatum* (Diesing, 1836).
Synonyms: *Amphistoma lunatum* Diesing, 1836; *Zygocotyle lunatum* (Diesing, 1836) Stunkard, 1916; *Zygocotyle creatosa* Stunkard, 1916; *Chiorchis lunatus* Travassos, 1931.
Hosts: *Anas platyrhynchos, A. melanotus, A. ipecutiri, A. moschata, A. platyrhynchos* (domestic) *A. rubripes, Marila americana, Mareca americana, Nyroca affinis, Querquedula dicors, Nettion delicata, Himantopus wilsonii, Cervus dichatomus, Bos taurus.*
Distribution: North and South America.
Reference: 30, 80, 106.

Cestoda

Key to Families of Cestoda

1. Organs of attachment on scolex consist of long, sucking grooves..DIPHYLLOBOTHRIDAE
Organs of attachment on scolex consist of four suckers; a rostellum may be present or absent 2
2. Suckers with auricular appendages on anterior border .....TETRABOTHRIDAE
Suckers without appendages 3
3. Rostellum armed with a double (rarely single) row of small, very numerous, hammer-shaped hooklets .....DAVAINEIDAE
Rostellum present or absent, armed or unarmed; hooks, if present not exceeding 25 or 30 4
4. Testes or more .....DILEPINIDAE
Testes 1 to 4 .....HYMENOLEPIDIDAE

Family DIPHYLLOBOTHRIIDAE Luhe, 1910

Key to Genera of Diphyllobothridae

1. Worm with incomplete external segmentation only at the anterior end.....*Ligula*
Adult worm with true external segmentation 2
2. A neck separating scolex from segments .....*Diphyllobothrium*
A neck absent, segmentation evident to scolex .....*Schistocephalus*

Genus *Diphyllobothrium* Cobbold, 1858

1. *Diphyllobothrium ditermus* (Creplin, 1825).
Synonyms: *Bothriocephalus ditremus* Creplin, 1825; *Dibothrum ditremum* (Creplin, 1825) Diesing, 1850; *Dibothriocephalus ditremus* (Creplin, 1825) Luhe, 1909; *Diphyllobothrum ditremus* (Creplin, 1825) Luhe, 1910.
Hosts: *Mergus serrator, Mergus merganser, Larus argentatus, L. canis, Colymbus arcticus.*
Distribution: Europe.
Reference: 53.

Genus *Ligula* Block, 1782

1. *Ligula intestinalis* (Goeze, 1782).
Synonyms: *Fasciola intestinalis* Goeze, 1782; *Ligula intestinalis* (Goeze, 1790) Gmelin, 1790.
Hosts: *Mergus merganser, M. serrator, Colymbus arcticus, Podiceps auritus, P.*

cristatus, P. grieseigena, Larus ridibundus, L. canus, Rissa tridactylia, Sterna hirundo, Chilidonias nigra, Anas platyrhynchos, Tringa nebularia, Ciconia ciconia, C. nigra, Nycticorax nycticorax, Haliaetus albicilla, Aquila chrysaetus, Corvus cornix.

Distribution: Northern Europe.

Reference: 53.

Genus *Schistocephalus* Creplin, 1829

1. *Schistocephalus solidus* (Muller, 1776).

Synonyms: *Taenia solida* Muller, 1776; *Phytis solida* (Muller, 1776) Zeder, 1803; *Bothriocephalus solidis* (Muller, 1776) Rudolphi, 1810; *Schistocephalus dimorphus* Creplin, 1829; *Taenia gasterostei* Fabricus, 1780; *Schistocephalus solidus* (Muller, 1776) Steerstrup, 1857; S. *gasterostei* (Fabricus, 1780) Luhe, 1910.

Hosts: *Podiceps cristatus, P. griseigena, Uria gryll, U. salge, Larus ridibundus, L. argentatus, L. marinus Sterna hirundo, Mergus merganser, M. serrator, Nyroca marila, Clangula hyemalis, Tringa totanus, Recurvirostra avocetta, Haematopus ostralegus, Fulica atra,* and also *Corvus cornix* and *C. corax.*

Distribution: Greenland and N. Europe.

Reference: 53.

Family Tetrabothriidae (Diesing, 1850)

Genus *Tetrabothrius* Rudolphi, 1819

1. *Tetrabothrius arcticus* Linstow, 1901.

Host: *Somateria mollisima.*

Distribution: North Europe and the Arctic.

Reference: 53.

Family Davaineidae Fuhrmann, 1907

Key to Genera of Davaineidae

Genital pores unilateral or irregularly alternate; uterus breaking down into egg capsules ..... *Raillietina*

Genital pores irregularly alternate, uterus persistent, rostellum wider than scolex.... ..... *Ophryocotyle*

Genus *Ophryocotyle* Freiis, 1870

1. *Ophryocotyle insignis* Lounberg, 1890.

Hosts: *Haematopus ostralegus, Mergus serrator.*

Distribution: Northern Europe.

Reference: 26.

Genus *Raillietina* Fuhrmann, 1920

1. *Raillietina anatina* (Fuhrmann, 1908)

Synonyms: *Davainea anatina* Fuhrmann, 1908; *Raillietina anatina* (Fuhrmann, 1908) Fuhrmann, 1920.

Host: *Anas platyrhynchos.*

Distribution: Italy.

Reference: 26, 85.

2. *Raillietina cyrtus* (Skrjabin, 1915).

Synonym: *Davainia cyrtus* Skrjabin, 1915.

Host: *Anas* sp.

Distribution: South America.

Reference: 96.

3. *Raillietina microcotyle* (Skrjabin, 1914).

Synonyms: *Davainea microcotyle* Skrjabin, 1914; *Raillietina microcotyle* (Skrjabin, 1914) Fuhrmann, 1920.

Host: *Anas platyrhynchos.*

Distribution: Italy.

Reference: 94.

4. *Raillietina parviuncinata* Meggitt and Po Saw, 1924.
Host: *Anas platyrhynchos.*
Distribution: Burma.
Reference: 65.

Family Dilepinidae (Stiles, 1896)
Key to Genera of Dilepinidae

1. Rostellum weakly developed or absent; without hooklets ..... *Unciunia*
Rostellum always present and bearing hooklets 2
2. Reproductive organs double in each segment ..... *Cotugnia*
Reproductive organs single in each segment 3
3. Genital pores unilateral ..... *Lateriporus*
Genital pores irregularly alternate 4
4. With a double crown of hooklets ..... *Biuterina*
With a singlge crown of hooklets ..... *Choanotaenia*

Genus *Lateriporus* Fuhrmann, 1907

1. *Latriporus biuterinus* Fuhrmann, 1908.
Host: *Oidemia fusca.*
Distribution: Europe, Brazil.
Reference: 26.
2. *Lateriporus teres* (Krabbe, 1869).
Synonyms: *Taenia cylindrica* Krabbe, 1869; *Hymenolepis teres* (Krabbe, 1869) Cohn, 1901; *Lateriporus teres* (Krabbe, 1869) Fuhrmann, 1907.
Hosts: *Somateria mollissima, Clangula hyemalis.*
Distribution: Northern Europe, Greenland.
Reference: 25, 26.

Genus *Choanotaenia* Railliet, 1896

1. *Choanotaenia borealis* (Linstow, 1905).
Synonyms: *Aporina borealis* Linstow, 1905; *Choataenia borealis* (Linstow, 1905) Fuhrmann (1908).
Host: *Clangula hyemalis.*
Distribution; Northern Russia.
Reference: 26.

Genus *Cotugnia* Diamare, 1893

1. *Cotugnia fastigata* Meggett, 1920.
Host: *Anas platyrhynchos.*
Distribution: Burma.
Reference: 4.

Genus *Biuterina* Fuhrmann, 1902

1. *Biuterina longiceps* (Rudolphi, 1819).
Host: *Cairina moschata.*
Distribution:
Reference: 27.

Genus *Unciunia* Skrjabin, 1914

1. *Unciunia acapillicirrosa* Moghe, 1933
Host: *Anas platyrhynchos (domestica).*
Distribution: India.
Reference: 67.

Family Hymenolepididae Railliet and Henry, 1909
Key to Genera of Hymenolepididae

1. One testis in each proglottid ..... *Haploparaxis*
More than one testis present 2
2. Two testes present ..... *Diorchis*
Three testes present 3

3. Excretory vessels 4 in number 4
   Excretory vessels 10 in number; strobilus segmented.....*Hymenofimbria*
4. Strobilus showing true segmentation, scolex well developed, no pseudoscolex.....
   ..... *Hymenolepis*
   Strobilus showing pseudosegmentation, a pseudoscolex present.....*Fimbriaria*

Genus *Hymenolepis* Weinland, 1858

1. *Hymenolepis abortiva* (Linstow, 1904).
   Synonyms: *Taenia abortiva* Linstow, 1904; *Weinlandia abortiva* (V. Linstow, 1904) Mayhew, 1924.
   Host: *Anas platyrhynchos.*
   Distribution: Europe.
   Reference: 4, 26, 47.
2. *Hymenolepis acicula* Rosseter, 1909.
   Host: *Anas platyrhynchos.*
   Distribution: Europe.
   Reference: 60.
3. *Hymenolepis aequabilis* (Rudolphi, 1810).
   Synonyms: *Taenia aequabilis* Rudolphi, 1810; *Dicranotaenia aequabilis* (Rudolphi, 1810) Stiles, 1896; *Drepanidotaenia aequabilis* (Rudolphi, 1810) Cohn, 1900; *Hymenolepis* (H) *aequabilis* (Rudolphi, 1810) Cohn, 1910.
   Hosts: *Cygnus cygnus, olar, Marila marila.*
   Distribution: Europe, Ural.
   Reference: 26, 87.
4. *Hymenolepis anatina* (Krabbe, 1869).
   Synonyms: *Taenia anatina* Krabbe, 1869; *Cysticercas taenia-anatinae* (Krabbe, 1869) Mrazek, 1891; *Drepaniotaenia anatina* (Krabbe, 1869) Railliet, 1896; *Delipes anatina* (Krabbe, 1869) Cohn, 1899; *Dicranotaenia anatina* (Krabbe, 1869) Wolffhugel, 1900; *Hymenolepis* (H) *anatina* (Krabbe, 1869) Cohn, 1901; *Cysticercus hymenolepidis-anatinae* Krabbe, 1869) Luhe, 1910.
   Hosts: *Anas platyrhynchos, Anser anser, Anas acuta, A. strepera, Cygnus olar, Fulica atra, Spatula clypeata.*
   Distribution: Europe.
   Reference: 4, 26, 87.
5. *Hymenolepis anceps* Linton, 1927.
   Host: *Mergus merganser.*
   Distribution: North America (Woods Hole).
   Reference: 49.
6. *Hymenolepis arcuata* Kowalewski, 1905.
   Synonym: *Weinlandia arcuata* (Kowalewski, 1905) Mayhew, 1924.
   Host: *Nyroca marila.*
   Distribution: Europe.
   Reference: 47, 87.
7. *Hymenolepis bisaccata* Fuhrmann, 1906.
   Host: *Cairina moschata.*
   Distribution:
   Reference: 24.
8. *Hymenolepis collaris* (Batsch, 1786).
   Synonyms: *Taenia collari nigro* Bloch, 1782; *Taenia collaris* Batsch, 1786; *T. torquata* Gmelin, 1790; *Alyhelminthus sinuosus* Zeder 1800; *Halysis torquata* (Gmelin, 1790) Zeder 1803; *H. sinuosa* (Zeder, 1800) Railliet, 1893; *Dilepis sinuosa* (Zeder, 1800) Cohn, 1899; *Hymenolepis collaris* (Batsch, 1786) Luhe, 1910; *Cysticercus hymenolepidis-collaris* (Batsch, 1786) Luhe, 1910; *Weinlandia collaris* (Batsch, 1786) Mayhew, 1925
   Hosts: *Anas platyrhynchos, Anser anser, Anas acuta, A. Penelope, Nyroca fuligula.*
   Distribution: Europe.
   Reference: 4, 26, 87.
9. *Hymenolepis compressa* (Linstow, 1892).

Synonyms: *Taenia compressa* Linstow, 1892; *Hymenolepis compressa* (Linstow, 1892) Kowalewski, 1904; *H. negarostris* Solowiow, 1911.
Hosts: *Anas platyrhynchos, Anser anser, Anas acuta, A. penelope, Nyroca ferina, N. fuligula, N. marila.*
Distribution: Europe, Asia, North America.
Reference: 26, 87.

10. *Hymenolepis coronula* (Dujardin, 1845).
Synonyms: *Taenia coronula* Dujardin, 1845; *Dicranotaenia coronula* (Dujardin, 1845) Railliet, 1892; *Carcocystis dicranotaenae-coronulae* (Dujardin, 1845) Railliet, 1893; *Cysticercus coronula* (Dujardin, 1845) Rosseter, 1897; *Drepanidotaenia coronula* (Dujardin, 1845) Luhe, 1910; *Hymenolepis coronula* (Dujardin, 1845) Cohn, 1901; *H. megalhystera* Linstow, 1905; *Hymenolepis (Weinlandia) coronula* (Dujardin, 1845) Mayhew, 1925.
Hosts: *Anas platyrhynchos, Anser anser, Anas penelope, Bucephala clangula, Nyroca marila, Tadorna tadorna.*
Distribution: Europe, Asia.
Reference: 26, 87.

11. *Hymenolepis echinocotyle* Fuhrmann, 1907.
Host: *Spatula clypeata.*
Distribution: Europe.
Reference: 25, 26, 87.

12. *Hymenolepis fallax* (Krabbe, 1869).
Synonyms: *Taenia fallax* Krabbe, 1869; *Lepidotrias fallax* (Krabbe, 1869) Cohn, 1899; *Hymenolepis (H) fallax* (Krabbe, 1869) Cohn, 1901.
Hosts: *Anas penelope, A. querquedula, Nyroca marila, Somateria mollissima.*
Distribution: Greenland and Far East.
Reference: 26.

13. *Hymenolepis fasciculata* (Rudolphi, 1810).
Synonyms: *Alyselminthus crenatus* (Goeze, 1782) Zeder, 1800; *Halysis crenata* (Goeze, 1782) Zeder, 1803 in part; *Taenia fasciata* Rudolphi, 1810; *T. setigera* (Froelich, 1789) Fenereisan, 1868; *Cysticercus taeniae-fasciata* (Rudolphi, 1810) Railliet, 1893; *Cercocystis drepanidotaenia-fasciatae* Railliet, 1893; *Dilepis fasciata* (Rudolphi, 1810) Cohn, 1899; *Hymenolepis fasciata* (Rudolphi, 1810) Cohn, 1910; *H. fasciculata* Ransom, 1909.
Hosts: *Anser anser, Anser albifrons* and *Anas penelope.*
Distribution: Europe.
Reference: 4, 26.

14. *Hymenolepis fragilis* (Krabbe, 1869).
Synonyms: *Taenia fragilis* Krabbe, 1869; *Drepanidotaenia fragilis* (Krabbe, 1869) Cohn, 1901; *Hymenolepis (H) fragilis* (Krabbe, 1869) Fuhrmann, 1906.
Hosts: *Anas crecca, A. streptera.*
Distribution: Europe, Ural, Far East.
Reference: 24, 26.

15. *Hymenolepis gracilis* (Zeder, 1803).
Synonyms: *Halysis gracilis* Zeder, 1803; *Taenia gracilis* (Zeder, 1803) Rudolphi, 1810; *Cysticercus taeniae-gracilis* (Zeder, 1803) Linstow, 1872; *Drepanidotaenia gracilis* (Zeder, 1803) Railliet, 1893; *Cysticercus gracilis* (Zeder, 1803) Rosseter, 1897; *Dilepis gracilis* (Zeder, 1803) Cohn, 1901; *Cysticercus hymenolepidis-gracilis* (Zeder, 1803) Luhe, 1910; *Weinlandia gracilis* (Zeder, 1803) Mayhew, 1925.
Hosts: *Anas platyrhynchos, Anser anser, Anas crecca, Anas penelope, A. streptera, Mergus merganser, M. serrator, Nyroca marila, Spatula clypeata, Tadorna tadorna.*
Distribution: Europe.
Reference: 4, 26.

16. *Hymenolepis groenlandica* (Krabbe, 1869).
Synonyms: *Taenia groenlandica,* Krabbe, 1869; *Drepanidotaenia groenlandica* (Krabbe, 1869) Cohn, 1901; *Hymenolepis (H) groenlandica* (Krabbe, 1869) Fuhrmann, 1906.

Host: *Clangula hyemalis.*
Distribution: Greenland.
Reference: 26, 87.

17. *Hymenolepis hamulacanthos* Linton, 1927.
Host: Marila americana.
Distribution: North America (Woods Hole).
Reference: 49.

18. *Hymenolepis introversa* (Mayhew, 1925).
Synonym: *Weinlandia introversa* Mayhew, 1925.
Host: *Anas platyrhynchos.*
Distribution: North America.
Reference: 60.

19. *Hymenolepis kowalewski* Baczynska, 1914.
Host: *Nyroca fuligula.*
Distribution: Europe.
Reference: 2, 60.

20. *Hymenolepis lamellata* Woodland, 1930.
Host: *Tadorna radjah.*
Distribution: Australia.
Reference: 133.

21. *Hymenolepis lanceolata* (Bloch, 1782).
Synonyms: *Taenia anseris* Bloch, 1782; *T. acutissima* Pallas, 1781, in part; *T. lanceolata* Bloch, 1782; *Halysis lanceolata* (Bloch, 1782) Zeder, 1803; *T. anserum* Rudolphi, 1810; *Hymenolepis lanceolata* (Bloch, 1782) Weinland, 1858; *Drepanidotaenia lanceolata* (Bloch, 1782) Railliet, 1893; *Cysticercus taeniae-lanceolatae* (Bloch, 1782) Mrazek, 1896; *Dilepis lanceolata* (Bloch, 1782) Cohn, 1899; *Cercocystis hymenolepidis-lanceolatae* Brumpt, 1910; *Cysticercus drepanidotaeniae-lanceolatae* (Bloch, 1782) Luhe, 1910.
Hosts: Man, *Anas platyrhynchos, Anser anser, Branta bernicola, Cygnus cygnus, Nettae rufina, Nyroca ferina.*
Distribution: Europe, Asia.
Reference: 4, 26, 87.

22. *Hymenolepis macranthos* (Linstow, 1877).
Synonyms: *Taenia macracanthos* Linstow, 1879; *Hymenopelis (H) macrocanthos* (Linstow, 1877) Fuhrmann, 1906.
Host: *Bucephala clangula.*
Distribution: Europe.
Reference: 26.

23. *Hymenolepis macrostrobiloides* Mayhew, 1925.
Host: *Anas rubripes.*
Distribution: North America.
Reference: 60.

24. *Hymenolepis megalops* (Nitzsch, 1829).
Synonyms: *Taenia anatis marilae* Creplin, 1825; T. megalops Nitzsch, 1829; *Hymenolepis megalops* (Nitzsch, 1829) Parona, 1899; *(Hymenolepis Weinlandia) megalops,* Mayhew, 1925.
Hosts: *Anas platyrhynchos, A. acuta, A. crecca, Cygnus cygnus, Nyroca fuligula, N. marila.*
Distribution: Europe, Asia, North and South America.
Reference: 26, 87.

25. *Hymenolepis micrancristrota* (Wedl. 1855).
Synonyms: *Taenia micrancristrota* Wed. 1855; Cohn, 1901.
Hosts: *Cygnus cygnus, Oidemia nigra.*
Distribution: Europe.
Reference: 26, 87.

26. *Hymenolepis microsoma* (Creplin, 1829).
Synonyms: *Taenia microsoma* Creplin, 1829; *Drepanidotaenia microsoma* (Creplin,

1829) Parona, 1899; *Dilepis microsoma* (Creplin, 1829) Cohn, 1899; *Hymenolepis microsoma* (Creplin, 1829) Cohn, 1901.

Hosts: *Anas penelope, Clangula hymealis, Nyroca marila, Oidemia fusca, O. nigra, Somateria mollissoma.*
Distribution: Europe.
Reference: 26, 87.

27. *Hymenolepis nitidulans* (Krabbe, 1882).
Synonyms: *Taenia nitidulans* Krabbe, 1882; *Echinocotyle nitidulans* (Krabbe, 1882).
Hosts: *Calidris alpina alpina, Charadrius hiaticula, Nyroca fuligula, Tradus merula.*
Distribution: Europe.
Reference: 26, 87.

28. *Hymenolepis nyrocae* Yamaguti, 1934.
Hosts: *Nyroca marila mariloides, Anas platyrhynchos platyrhynchos.*
Distribution: Japan.
Reference: 137.

29. *Hymenolepis octacantha* (Krabbe, 1869).
Synonyms: *Taenia octacantha* Krabbe, 1869; *Drepanidotaenia octacantha* (Krabbe, 1869) Cohn, 1901; *Hymenolepis octacantha* (Krabbe, 1869) Cohn, 1901; *Weinlandia octacantha* (Krabbe, 1869) Mayhew, 1924.
Hosts: *Anas platyrhyncha, A. acuta, Spatula clypeata, Anas crecca, A. strepera.*
Distribution: Europe.
Reference: 26, 60, 87.

30. *Hymenolepis papillata* Fuhrmann, 1906.
Synonym: *Weinlandia papillata* (Fuhrmann, 1906) Mayhew, 1924.
Host: *Cairina moschata.*
Distribution: South America?
Reference: 24, 26, 87.

31. *Hymenolepis parvula* Kowalewski, 1905.
Synonym: *Weinlandia parvula* (Kowalewski, 1905) Mayhew, 1925.
Host: *Anas platyrhynchos.*
Distribution: Europe.
Reference: 26, 87.

32. *Hymenolepis pigmentata* (Linstow, 1872)
Synonyms: *Taenia pigmentata* Linstow, 1872; *Hymenolepis (H) pigmentata* (Linstow, 1872) Fuhrmann, 1906.
Host: *Nyroca marila.*
Distribution: Europe.
Reference: 26, 87.

33. *Hymenolepis querquedulae* Fuhrmann, 1913.
Synonym: *Weinlandia querquedulae* (Fuhrmann, 1913) Mayhew, 1924.
Host: *Querquedula discors.*
Distribution: South America, Antilles.
Reference: 60, 87.

34. *Hymenolepis rarus* Skrjabin, 1914.
Synonym: *Weinlandia rarus* (Skrjabin, 1914) Mayhew, 1924.
Host: *Netta rufina* (Caecum).
Distribution: Asia.
Reference: 94.

35. *Hymenolepis rosseteri* (Blanchard, 1891).
Synonyms: *Echinocotyle rosseteri* Blanchard, 1891; *Taenia rosseteri* (Blanchard, 1891) Braun, 1894; *Hymenolepis (E) rosseteri* (Blanchard, 1891) Fuhrmann, 1906; *Cysticercus echinocotylis rosseteri* (Blanchard, 1891) Luhe, 1910.
Host: *Anas platyrhynchos.*
Distribution: England.
Reference: 26, 60, 87.

36. *Hymenolepis sagitta* (Rosseter, 1906; *Hymenolepis (H) sagitta* (Rosseter, 1906) Fuhrmann, 1908.
Host: *Anas platyrhynchos.*
Distribution: Europe.
Reference: 26, 60, 87.

37. *Hymenolepis setigera* (Froelich, 1789).
Synonyms: *Taenia setigera* Froelich, 1789; *Alyselhelminthus setigerus* (Froelich, 1789) Zeder, 1800; *Halysis setigera* (Froelich, 1789) Zeder, 1803; *Taenia fasciata* (Rudolphi, 1810) Fenereisen, 1868; *Cysticercus taeniae-setigerae* (Froelich, 1789) Linstow, 1892; *Drepanidotaenia setigera* (Froelich, 1789) Railliet, 1893; *Cercocystis drepanidotaeniae- setigerae* (Froelich, 1789) Railliet, 1893; *Dilepis setrigera* (Froelich, 1789) Cohn, 1899; *Hymenolepis (H) setigera* (Froelich, 1789) Cohn, 1901; *Cysticercus hymenolepidis- setigerae* (Froelich, 1789) Luhe, 1910.
Hosts: *Anser anser, Anser fabalis, Branta bernicola, B. leucopsis, Cygnus cygnus, Cygnus olar, Nyroca ferina.*
Distribution: Europe.
Reference: 26, 60, 87.

38. *Hymenolepis soloviowi* Skrjabin, 1914.
Host: *Nyroca nyroca.*
Distribution: Asia.
Reference: 94.

39. *Hymenolepis tenerrina* (Linstow, 1882).
Synonyms: *Taenia tenerrina* Linstow, 1882; *Hymenolepis (H) tenerrina* (Linstow, 1882) Fuhrmann, 1906.
Host: *Nyroca marila.*
Distribution: Europe.
Reference: 26, 60, 87.

40. *Hymenolepis tenuirostris* (Rudolphi, 1819).
Synonyms: *Taenia tenuirostris* Rudolphi, 1819); *Cysticercus taeniae tenuirostris* (Rudolphi, 1819) Linstow, 1892; *Drepanidotaenia tenuirostris* (Rudolphi, 1819) Railliet, 1893; *Cysticercus tenuirostris* (Rudolphi, 1819) Rosseter, 1897; *Dilepis tenuirostris* (Rudolphi, 1819) Cohn, 1901; *Cysticercus hymenolepidis-tenuirostris* (Rudolphi, 1819) Luhe, 1910.
Hosts: *Anas platyrhynchos, Anser anser, Mergus albellus, M. merganser, M. serator, Nyroca fuligula, N. marila, Oidemia fusca, Rissa tredactyla.*
Distribution: Europe, America.
Reference: 26, 60, 87.

41. *Hymenolepis teresoides* Fuhrmann, 1906.
Synonyms: *Taenia teres* Linstow, 1889, after Krabbe, 1869; *Weinlandia teresoides* (Fuhrmann, 1906) Mayhew, 1924.
Host: *Anas strepera.*
Distribution: Europe.
Reference: 24, 26, 60, 87.

42. *Hymenolepis trichorhynchus* Yoshida, 1910.
Host: *Anas crecca.*
Distribution: Japan.
Reference: 60.

43. *Hymenolepis trifolium* Linstow, 1905.
Host: *Anas platyrhynchos.*
Distribution: Europe.
Reference: 26, 60, 87.

44. *Hymenolepis tritesticulata* Fuhrmann, 1907.
Synonym: *Weinlandia tritesticulata* (Fuhrmann, 1907) Mayhew, 1924.
Host: *Mergus merganser.*
Distribution: Europe.
Reference: 26, 60, 87.

45. *Hymenolepis venusta* (Rosseter, 1897).
Host: *Anas platyrhynchos* (dom.)
Distribution: Europe.
Reference: 26, 60, 87.

Genus *Diorchis* Clerc, 1903

1. *Dirochis acuminata* (Clerc, 1902).
Synonyms: *Dreparidotaenia* Clerc, 1902; *Taenia acuminata* (Clerc, 1902) Clerc, 1903; *Diorchis acuminata* (Clerc, 1902) Clerc, 1903; *Hymenolepis acuminata* (Clerc, 1902) Fuhrmann, 1906.
Hosts: *Anas crecca, A. penelope, A. strepera, Fulica atra.*
Distribution: Europe, Asia, North America.
Reference: 24, 61, 87.

2. *Diorchis bulbodes* Mayhew, 1929.
Host: *Anas platyrhynchos.*
Distribution: North America.
Reference: 61.

3. *Diorchis excentricus* Mayhew, 1925.
Host: *Erismatura jamaicensis.*
Distribution: United States.
Reference: 61.

4. *Diorchis flavescens* (Krefft, 1871).
Hosts: *Anas superciliosa, Spatula rhynchotis, Nettion castaneum, Aythya australis.*
Distribution: Australia.
Reference: 61.

5. *Diorchis kodonoides* Mayhew, 1929.
Host: *Querquedula discors.*
Distribution: North America.
Reference: 61.

6. *Diorchis microcirrosa.*
Host: *Querquedula discors.*
Distribution: North America.
Reference: 61.

7. *Diorchis nyrocae* Yamaguti, 1934.
Host: *Nyroca fuligula.*
Distribution: Japan.
Reference: 137.

8. *Diorchis parviceps* (Linstow, 1872).
Synonyms: *Taenia parviceps* Linstow, 1872; *Diorchis parviceps* (Linstow, 1872) Linstow, 1904; *Hymenolepis parviceps* (Linstow, 1872) Fuhrmann, 1906.
Host: *Mergus serrator.*
Distribution: Europe.
Reference: 61, 87.

9. *Diorchis spinata* Mayhew.
Host: *Chaulelasmus streperus.*
Distribution: North America.
Reference: 61.

Genus *Haploparaxis* Clerc, 1903

1. *Haploparaxis elisae* Skrjabin, 1914.
Host: *Nyroca nyroca.*
Distribution: Asia, Turkestan.
Reference: 94.

2. *Haploparaxis fuligulosa* Solowiow, 1911.
Host: *Nyroca fuligula.*
Distribution: Europe.

Reference: 94.

3. *Haploparaxis furcigera* (Nitzsch, 1819).

Synonyms: *Taenia lineata* Bloch, 1779; *T. trilineata* Batsch, 1786; *T. longirostris* Froelich, 1802; *T. furcigera* Nitsch in Rudolphi, 1819; *T. rhomboidea* Dujardin, 1845; *T. comica* Molin, 1855; *Dicranotaenia-furcigera* (Nitzsch, 1819) Stiles, 1896; *Dilepis furcigera* (Nitzsch, 1819) Cohn, 1899; *Drepanidotaenia furcigera*, (Nitzsch, 1819) Cohn, 1901; *Hymenolepis furcigera* Nitzsch, 1819) Cohn, 1901; *Haploparaxis furcigera* (Nitzsch, 1819) Fuhrmann, 1908.

Hosts: *Anas platyrhyncha, Anas crecca, Nyroca ferina.*
Distribution: Europe, Asia.
Reference: 26, 53.

4. *Haploparaxis japanensis* Yamaguti, 1934.
Host: *Anas platyrhynchos.*
Distribution: Japan.
Reference: 137.

Genus *Hymenofimbria* Skrjabin, 1914

1. *Hymenofimbria merganseri* Skrjabin, 1914.
Host: *Mergus merganser.*
Distribution: Russia.
Reference: 60, 94.

Genus *Fimbriaria* Froelich, 1802

1. *Fimbriaria falciformis* Linton, 1927.
Hosts: *Oidemia perspicillata, Clangula hyemalis, Fulica americana.*
Distribution: North America (Woods Hole).
Reference: 49.

2. *Fimbriaria fasciolaris* (Pallas, 1781).

Synonyms: *Taenia fasciolaris* Pallas, 1781; *T. mallens* Goeze, 1782; *Alyselminthus mallens* (Goeze, 1782 Zeder, 1800; *Fimbriaria mitra* Froelich, 1802; *Halysis mallens* (Goeze, 1782) Zeder, 1903; *Taenia pediformis* Krefft, 1871; *Epision plicatus* Linton, 1892; *Fimbriaria fasciolaris* (Pallas, 1781) *Wolfhugel*, 1899; *Notobothrium arcticum* Linstow, 1905; *Cysticercus fimbriariae-fasciolaris* (Pallas, 1781) Luhe, 1910.

Hosts: *Anas platyrhynchos, Anser anser, Gallus gallus, Anas crecca, A. penelope, A. querquedulae, Bucephala changula, Clangula hyemalis, Mergus merganser, M. serrator, Netta rufina, Nyroca marila, Oidemia fusca, Somateria mollissima.*

Distribution: Cosmopolitan.
Reference: 26, 53, 60, 87.

3. *Fimbriaria plana* Linstow, 1915.
Host: *Anas platyrhynchos.*
Distribution: Europe.
Reference: 60.

Genus *Diploposthe* Jacobi, 1896

1. *Diploposthe laevis* (Bloch, 1782).

Synonyms: *Taenia laevis* Bloch, 1782; *Halysis laevis* (Bloch, 1782) Zeder, 1803; *Taenia bifaria* Siebold, 1848, in part; *T. trichosoma* Linstow, 1882; *Cotugnia bifaria* (Siebold, 1848) Stiles, 1890; *Diploposthe laevis* (Bloch, 1782) Jacobi, 1896; *D. lata*, Fuhrmann, 1900; *D. singeneris* Kowalewski, 1903.

Hosts: *Anas platyrhyncha, A. cercca, A. querquedula, A. strepera, Bucephala clangula, Netta rufina, Nyroca ferina, N. fuligula, N. marila, N. nyroca, Oidemia nigra, Spatula clypeata.*

Distribution: Europe, Asia, North America.
Reference: 26, 87.

Nematoda

Key to Families of Nematoda

1. Esophagus consisting of a narrow tube running through the center of a row of single cells for most of its length ..... TRICHURIIDAE
   Esophagus muscular, trepartite 2
2. Males with a membranous bursa supported by rays; buccal capsule present or absent; eggs usually thin shelled 4
   Males without a well defined bursa 3
3. Heteroxenous forms; usually with two lips 7
   Monoxenous forms; usually with three lips, males usually with two spicules 6
4. A buccal capsule present; usually relatively thick forms ..... SYNGAMIDAE
   A buccal capsule absent; usually slender, hair-like forms 5
5. A small buccal capsule present; or with 4 papillae and epaulets ..... AMIDOSTOMIDAE
   Head simple; no buccal capsule or cephalic structures ..... TRICHOSTRONGYLIDAE
6. Mouth with three lips or without lips, males with a preanal sucker which may be limited by a ring, or formed by a simple longitudinal depression ..... HETERAKIDAE
   Mouth with three lips, or with three main lips and three intermediate lips; male without preanal sucker ..... ASCARIDAE
7. Male with a closed muscular bursal cup at tail end; female with terminal anus ..... DIOCTOPHYMIDAE
   Male without bursal cup; anus of female subterminal 8
8. In orbital region or respiratory tract of host ..... THELAZIIDAE
   In digestive tract of host 9
9. Marked sexual dimorphism. Female robust, the male slender, in glands of proventriculus ..... TETRAMERIDAE
   Sexes not dimorphic, anterior region with cuticular ornaments ..... ACUARIIDAE

Family TRICHURIDAE Railliet, 1915

Genus *Capillaria* Zeder, 1900

1. *Capillaria anatis* (Schrank, 1790).
   Synonyms: *Trichocephalus anatis* Schrank, 1790; *Trichocephalus capillaris* Rudolphi, 1809; *Capillaria tumida* Zeder, 1803; *Trichosoma brevicolle* Rudolphi, 1819.
   Hosts: *Anser ferus, Harelda glacialis, Merganser castor, Oidemia fusca,* and *Querquedula querquedula.*
   Distribution: Europe.
   Reference: 17, 103.
2. *Capillaria contorta* (Creplin, 1839).
   Synonyms: *Trichosoma contorta* Creplin, 1839; *Capillaria contorta* (Creplin, 1839) Travassos, 1915.
   Hosts: *Anas platyrhynchos, Accipiter nisus, Nettion crecca, Larus canus, L. ridibundus, Charadrius hiaticula, Recurvirostra avocetta, Philomachus pugnax, Corvus corone, C. cornix, C. frugilegus, Colvenus monedula spermologus, sturnus vulgaris, Erithacus rubecula, Buteo butea, Vanellus vanellus.*
   Distribution: Europe, Asia.
   Reference: 17, 103.
3. *Capillaria spinulosa* (Linstow, 1890).
   Synonyms: *Trichosoma spinulosa* Linstow, 1890; *Capillaria spinulosa* (Linstow, 1890) Travassos, 1915.
   Host: *Nyroca ferina.*
   Distribution: Europe.
   Reference: 17, 103.

Family TRICHOSTRONGYLIDAE Leiper, 1912

Genus *Trichostrongylus* Loos, 1905.

1. *Trichostrongylus tenuis* (Mehlis, 1846).
   Synonyms: *Strongylus tenuis* Mehlis, 1846; Strongylus serratus Linstow, 1876.
   Hosts: *Anas boschas, A. boschos domesticus, Anser albifrons, A. anser, A. cinereus, A. cinereus domesticus, A. domesticus, A. ferus, A. ferus domesticus, Gallus gaallus,*

Otis tarda, *Perdix cinerea*, and *Phasianus colchicus*.
Distribution: Europe, Asia, North America.
Reference: 17, 18, 19.

Family AMIDOSTOMIDAE Baylis and Daubney, 1926
Key to Genera of Amidostomidae

1. Head with 4 outwardly directed papillae and 2 posteriorly directed epaulets.
Spicules divided into 3 branches ..... *Epomidiostomum*
Head without 4 outwardly directed papillae and 2 posteriorly directed epaulets.
Spicules divided into 2 branches ..... *Amidostomum*

Genus *Amidostomum* Railliet and Henry, 1909

1. *Amidostomum acutum* (Lundahl, 1848).
Synonym: *Strongylus acutus* Lundahl, 1848.
Hosts: *Anas crecca*, *Oidemia fusca*, *Oidemia nigra*, *Somateria mollissima*, *Nyroca fuligula*, and *Fuligula cristata*.
Distribution: Europe (Sweden).
Reference: 17, 103.

2. *Amidostomum anseris* (Zeder, 1800).
Synonyms: *Ascaris mucronata* Froelich, 1791, *Strongylus anseris* Zeder, 1800, in part; *Strongylus nodulosus* Rudolphi, 1803; *Strongylus nodularis* Rudolphi, 1809; *Trichostrongylus nodularis* (Rudolphi, 1809) Shipley, 1909; *Amidostomum nodulosum* Rudolphi, 1803) Seurat, 1918.
Hosts: *Anas querquedula*, *Anser acuta*, *Anser albifrons*, *Anser anser*, *A. a. domestica*, *A. cinereus*, *A. clangula*, *A. crecca*, *A. fabalis*, *A. fuligula*, *A. fusca*, *A. leucops*, *A. marila*, *A. mollissima*, *A. nigra*, *A. penelope A. segetum*, *Chloephaga poliocephala*, *Fulica atra*, *Fuligula cristata*, *F. marila*, *Gallinula chloropus*, *Nyroca clangula*, *N. fuligula*, *N. marila*, and *Somateria dresseri*.
Distribution: Europe, Asia, Africa, and North America.
Reference: 17, 103

3. *Amidstomum monodon* (Linstow, 1882).
Synonyms: *Strongylus monodon* Linstow, 1882; *Sclerostoma monodon* (Linstow, 1882) Stossich, 1889; *Amidstomum monodon* (Linstow, 1882) Skrjabin, 1915.
Host: *Oidemia nigra*.
Distribution: Europe.
Reference: 17, 103.

Genus *Epomidiostomum* Skrjabin, 1916

1. *Epimidiostomum orispinum* (Molin, 1861).
Synonyms: *Strongylus anseris* Zeder, 1800 in part; *Strongylus orispinus* Molin, 1861.
Hosts: *Anas albifrons*, *A. anser domestica*, *A. anser fera*, *A. clangula*, *A. crecca*, *A. fuligula*, *A. fusca*, *A. leucops*, *A. mollisima*, *A. nigra*, *A. penelope*. *A. segetum*, *Anser anser*, *Fulica atra*.
Distribution: Europe and Africa.
Reference: 17, 103.

2. *Epimidiostomum querquedulae* Boulenger, 1926.
Host: *Anas crecca*.
Distribution: Egypt.
Reference: 140.

3. *Epimidiostomum uncinatum* (Lundahl, 1848).
Synonyms: *Strongylus uncinatus* Lundahl, 1848; *Epomidiostomum anatinus* Skrjabin, 1916.
Hosts: *Anas acuta*, *A. nigra*, *A. penelope*, *A. boschas domestica*, *Anser albifrons*, *Fuligula nigra*, *Mareca penelope*, *A. p. platyrhynchos*.
Distribution: Europe, Central Asia, and Africa.
Reference: 17, 103.

Family SYNGAMIDAE Leiper, 1912
Key to Genera of Syngamidae

Worms permanently jointed in copula.....*Syngamus*
Worms not permanently joined in copula.....*Cyathostoma*

Genus *Syngamus* von Siebold, 1836

1. *Syngamus trachea* (Montagu, 1811).
   Synonyms: *Fasciola trachea* Montagu, 1811; *Syngamus trachealis* Siebold, 1836; *Syngamus primitivus* Molin, 1860; *Strongylus primitivus* (Molin, 1860) Hutyra and Marek, 1910; *S. trachealis* (Siebold, 1836) Diesing, 1851.
   Hosts: *Meleagris gallopavo, Gallus gallus, Anas boschas, Anser anser, Ciconia alba, C. nigra, Corvus cornix, C. corone, C. frugilegus, C. monedula; Cypselus apus, Lagopus scoticus, Otis tarda, Pavo cristatus, Pelecanus onocrotalus, Perdix cinerea, Phasianus colchicus, Phasianus gallus, Phasianus pictus, P. reevesi, Pica caudata, Pica pica, Picus canus, P. viridis, Purrocorac alpinus, Stix noctua, Strunus vulgaris, Tetao uragallus..*
   Distribution: Cosmopolitan.
   Reference: 17, 103.

Genus *Cyathostoma* Blanchard, 1849

1. *Cyathostoma bronchialis* (Muehlig, 1884).
   Synonym: *Syngamus bronchialis* Muehlig, 1884.
   Hosts: *Anas boschas domestica, Anser cinereus domesticus,* and *Cascara cascara.*
   Distribution: Europe, Asia.
   Reference: 17, 103.
2. *Cyathostoma tadorna* (Chatin, 1874).
   Synonyms: *Sclerostoma tadornae* (Chatin, 1874) Linstow, 1878; *Syngamus tadornae* (Chatin, 1874) Railliet, 1898.
   Host: *Tadorna tadorna.*
   Distribution: Europe.
   Reference: 17, 103.

Family HETERAKIDAE Railliet and Henry, 1914
Key to Genera of Heterakidae

Esophageal bulb lacking; caudal alae feebly developed.....*Ascaridia*
Esophageal bulb present; caudal alae well developed; with head cordons.....*Heterakis*

Genus *Heterakis* Dujardin, 1845

1. *Heterakis caudata* Linstow, 1906.
   Hosts: *Anas sponsa* and *Lampronessa sponsa.*
   Distribution: Europe (Germany).
   Reference: 17, 103.
2. *Heterakis dispar* (Schrank, 1790).
   Synonym: *Ascaris dispar* (Schrank, 1790).
   Hosts: *Anser domesticus, A boschas domestica, A. canadensis, A. leucopsis, A. moschata, A. tadorna, Anser anser, A. cinereus, A. fabalis, A. segetum, Bernicla sandwichensis, Sturna passerina, Stix passerina, Tadorna tadorna.*
   Distribution: United States, Europe, and Asia.
   Reference: 17, 103.
3. *Heterakis gallinae* (Gmelin, 1790).
   Synonyms: *Ascaris gallinae* Gmelin, 1790; *Ascaris vesicularis* Froelich, 1791; *Heterakis vesicularis* (Froelich, 1791) Dujardin, 1845; *Heterakis papillosa* Railliet, 1885.
   Hosts: *Anas boschas domestica, A. tadorna, Anser anser, A. cinereus domesticus, Bonasa sylvestris, Ceriornis satyra, Chenopsis atrata, Chrysolophus pictus, Colinus virginianus, Corvus cajanus, Coturnix communis, C. dactylisonans, Cupidonia cupido, Gallus gallus, Grossiptodon manschuricum, Lagopus mutus, L. scoticus, Meleagris gallopavo, Numida melagris, Ortyx virginianus, Otis tarda, O. tetrax, Pavo cristatus, Perdix cinerea, P. coturnix, P. perdix, P. saxatilis, Phasianus colchicus, P. gallus, P. nycthe-*

merus, P. pictus. P. veneratus. P. versicolor. Tadorna tadorna. Tetrao bonasia, T. lagopus, T. urogallus.

Genus *Ascaridia* Dujardin, 1845

1. *Ascaridia galli* (Schrank, 1788).
   Synonyms: *Ascaris galli* Schrank, 1788; *Ascaris gallopavonis* Gmelin, 1790; *Ascaris gibbosa* Rudolphi, 1809; *Ascaris perspicillum* Rudolphi, 1803; *Fusaria inflexa* Zeder, 1800; *Ascaris inflexa* (Zeder, 1800) Dujardin, 1845; *Heterakis inflexa* (Zeder, 1800) Schneider, 1866; *H. perspicillum* (Rudolphi, 1803) Railliet, 1803; *Ascaridia perspicillum* (Rudolphi, 1803) Dujardin, 1845.
   Hosts: *Anas acuta, A. boschas domestica, A. b. fera, A. moschata, Cairina moschata, Gallus gallus, Ithagenes cruentus, Numida meleagris, Phasianus gallus, Tetrao bonasia, T. urogallus.*

2. *Ascaridia lineata* (Schneider, 1866).
   Synonyms: *Heterakis lineata* Schneider, 1866; *Ascaridia hamia* Lane, 1914.
   Distribution: Cosmopolitan.
   Reference: 17, 103.
   Hosts: *Anas boschas domesticus, Bonasa umbellus, Gallus gallus,* goose.
   Distribution: North America, South America, Asia, Africa, and Europe.
   Reference: 17, 103.

3. *Ascaridia perspicillum* (Rudolphi, 1803).
   Synonyms: *Ascaris gallopavonis* Grielin, 1789; *Fusaria reflexa* Zeder, 1800 in part; *Fusaria strumosa* Zeder, 1800 in part; *Ascaris perspicillum* Rudolphi, 1803; *Ascaris gibbosa* Rudolphi, 1809; *Ascaris inflexa* (Zeder, 1800) Rudolphi, 1819; *Ascaris funiculus,* Deslongchamps, 1824.
   Hosts: *Gallus gallus, Numida meleagris, Meleagris gallopavo, Lyurus tetrix, Tetrao urogallus, Tetrastis bonasia ruprestris, Turdus viscivorus, Anas acuta.*
   Distribution: Europe, Asia.
   Reference: 17, 103.

4. *Ascaridia styphlocerca* (Stossich, 1904).
   Synonym: *Heterakis styphlocerca* (Stossich, 1904).
   Hosts: *Anas platyrhynchos, Gallus gallus.*
   Distribution: South Africa.
   Reference: 17, 103.

Family Ascaridae Baird, 1853
Key to Genera of Ascaridae

Intestinal cecum and esophageal appendix both present ..... *Contracaecum*
Intestinal cecum present; esophagus appendix absent ..... *Porrocaecum*

Genus *Porrocaecum* Railliet and Henry, 1912

1. *Porrocaecum crassum* (Deslongchamps, 1824).
   Synonym: *Ascaris crassa* Deslongchamps, 1824.
   Hosts: *Anas boschas, A. b. domestica, A. moschata, Numida meleagris.*
   Distribution: Europe (Germany and France).
   Reference: 17, 103.

2. *Porrocaecum ensicaudarum* (Zeder, 1800).
   Synonyms: *Fusaria ensicaudata* Zeder, 1800; *Ascaris ensicaudata* (Zeder, 1800) Rudolphi, 1809.
   Hosts: *Acrocephalus arundineaceus, Alauda species, Anas boschas, Charadrius* dubius, *C. hiaticula, C. morinellus, C. pluvialis, Gallinula chloropus, Himantopus melanopterus, Luscinia philomela, Merula nigra, Mimus polyglottus Motacilla alba, Oedicnemus crepitans, Rooks, Pica caudata, Pluvialis apricarius, Salicaria turdoides, Squatarola helvitica, Sturmus vulgaris, Sylvia turdoides, Turdus iliacus, T. musicus, T. merula, T. pilaris, T. saxatilis, T. torquatus, T. viscivorus, Vanellus cristatus, V. melanogaster.*
   Distribution:
   Reference: 17, 103.

Genus *Contracaecum* Railliet and Henry, 1912

1. *Contracaecum microcephalum* (Rudolphi, 1809)
   Synonyms: *Ascaris microcephala* Rudolphi, 1809; *Kathleena arcuata* Gedoelst, 1916; *Contracaecum quadricuspe* Walton, 1923.
   Hosts: *Anas boschas, Anas domestica, Ardea cinerea, A. comata, A. herodias, A. minor, A. nycticorax, A. purpurea, A. species, A. stellaris, Ardelolo grayi, A. ralloides, Botauras mugitans, B. stellaris, Butorides cirescens virescens, Ciconia alba, C. nigra, Herodias egretta, H. tricolor, Nyctiardea grisea, Nycticorax europaeus, N. nycticorax.*
   Distribution: North America, Europe, Asia, and Africa.
   Reference: 17, 103.
2. *Contracaecum micropapillatum* (Stossich, 1890).
   Synonyms: *Ascaris micropapillata* Stossich, 1890.
   Hosts: *Pelecanus species, P. crispus, P. erythrorhynchos,* and *Glaucionetta clangula.*
   Distribution: Europe, and North America.
   Reference: 17, 103.
3. *Contracaecum speculigerum* (Rudolphi, 1809).
   Synonyms: *Ascaris spiculigerum* Rudolphi, 1809.
   Hosts: *Anas clangula, Merganser castor, Mergus merganser,* and many other fish-eating birds.
   Distribution: Europe, South America, Africa, Asia, Australia, North America.
   Reference: 17, 103.
4. *Contracaecum turkestanicum* Skrjabin, 1923.
   Host: *Mergus merganser.*
   Distribution: Turkestan.
   Reference: 140.

Family ACUARIIDAE Seurat, 1913

Key to Genera of Acuariidae

1. With cordons, epaulets, or other homologous structures 2
   Cephalic ornimentation a crown or hood with festooned edge; lateral papillae tricuspid ..... *Yseria*
2. Cephalic ornimentation consists of a narrow denticulated collar which is the margin of a depression surrounding the head at the base of the lips; cervical papillae large and crescent-shaped; with numerous teeth ..... *Streptocara*
   Ornimentation consisting of cordons 3
3. Cordons not recurrent, but anastomosing ..... *Echinuria*
   Cordons recurrent and anastomosing, forming a loop directly after their origin on the head ..... *Cosmocephalus*

Genus *Cosmocephalus* Molin, 1858

1. *Cosmocephalus obvelatus* (Creplin, 1825).
   Synonyms: *Apiroptera obvelata* Creplin, 1825, *Filaria obvelata* (Creplin, 1825) Linstow, 1877; *Dispharagus obvelatus* (Creplin, 1825) Linstow, 1909, *Histiocephalus spiralis* Diesing, 1851; *Cosmocephalus papillosus* Molin, 1859, *Dispharagus papillosus* (Molin, 1859) Stossich, 1898; *Cosmocephalus alatus* Molin, 1860.
   Hosts: *Actitis hypoleucus, A. macularia, Alca torda, Catorrhactes pachyrhynchus, Larus argentatus, L. argentoides, L. canus, L. fuscus, L. marinus, L. maximus, L. medius, L. ridibundus, Mergus serrator, Puffinus kuhli, Sterna arctica, S. risoria, Totanus hypoleucus, T. maculatus, T. fuscus, Tringoides hypoleucus, Uria grylle.*
   Distribution: Europe, Africa, and North America.
   Reference: 17, 103.

Genus *Echinuria* Soloviev, 1912

1. *Echinuria jagadormata* Soloviev, 1912.
   Host: *Anas boschas.*
   Distribution: Turkestan.
   Reference: 17, 103.
2. *Echinuria uncinata* (Rudolphi, 1819).
   Synonyms: *Spiroptera uncinata* Rudolphi, 1819; *Dispharagus uncinatus* (Rudolphi, 1819)Railliet, 1893; *Acuaria (Hamannia) uncinata* (Rudolphi, 1819) Railliet, Henry

and Sisoff, 1912; *Hammania uncinata* (Rudolphi, 1819) Stiles and Hassell, 1920.
Hosts: *Anas boschas domestica, A. penelope, A. rubripes, Anser cinereus domesticus, Cygnus olar domesticus, Nettion carolinense.*
Distribution: Europe, Africa, North America.
Reference: 17, 103.

Genus *Streptocara* Railliet, Henry and Sisoff, 1912

1. *Streptocara crassicauda* (Creplin, 1829).
Synonyms: *Spiroptera crassicauda* Creplin, 1829; *Dispharagus crassicauda* (Creplin, 1829) Molin, 1860; *Streptocara crassicauda anseri* Skrjabin, 1916.
Hosts: *Anas clangula, A. glacialis, A. tadorna, A. fusca, A. boschas, Alca torda, Bernicla sandwichensis, Bucephala clangula, Colymbus arcticus, C. rufovulgaris, C. septentrionalis, Harelda glacialis, Mergus serrator, Mergus merganser, Nyroca clangula, Oidemia fusca, Tadorna tadorna.*
Distribution: Europe and Asia.
Reference: 17, 103.

Genus *Yseria* Gedoelst, 1919

1. *Yseria californica* Gedoelst, 1919.
Host: *Oidemia deglandi.*
Distribution: United States (California).
Reference: 17, 103.

Family THALAZIIDAE Railliet, 1916
Genus *Oxyspirura* Drash in Stossich, 1897

1. *Oxyspirura parovatum* Sweet, 1910.
Host: *Cairina moschata,* chicken, pigeon.
Distribution: Australia.
Reference: 4, 103, 140.

Family TETRAMERIDAE Travassos, 1914
Genus *Tetrameres* Creplin, 1846

1. *Tetrameres americana* Cram, 1927.
Hosts: *Gallus gallus,* ducks.
Distribution: North America.
Reference: 17, 42.
2. *Tetrameres crami* Swales, 1933.
Hosts: *Anas boschas domesticus, Anas platyrhynchos, Anas rubripes, Chaulelasmus streperus, Mareca americana, Nettion carolinense, Querquedula discors, Spatula clypeata, Dafila acuta, Nyroca marila, N. affinis* and *Glaucionetta clangula.*
Distribution: Canada, and probably North America.
Reference: 110, 112.
3. *Tetrameres fissispina* (Diesing, 1861).
Synonyms: *Tropidocerca fissispina* Diesing, 1861; *Tropisurus fissispinus* (Diesing, 1861) Neumann, 1888; *Acanthophorus tenuis* Linstow, 1876; *Acanthorphorus horridus* Linstow, 1876; *Tropidocerca tenuis* Linstow, 1899; *Filaria pulicis* Linstow, 1894; *Spiroptera pulicis* (Linstow, 1894) Linstow, 1909.
Hosts: *Anas boschas, A. b. domestica, A. b. fera, Columba livia domestica, Cygnus melanocoryphus, Fulica atra, Meleagris gallopavo, Mergus merganser, Nyroca ferina, Podiceps fluviatilis.*
Distribution: North America, Asia, Europe, Africa.
Reference: 17, 103.
4. *Tetrameres gigas* Travassos, 1919.
Synonyms: *Tetrameres inflata* of Zuern, 1882, not Diesing, 1861 of Travassos.
Host: *Anas boschas domestica.*
Distribution: South America, Brazil.
Reference: 17.
5. *Tetrameres gynaecophila* (Molin, 1858).
Synonyms: *Tropidocerca gynaecophila* Molin, 1858; *Tetrameres gynaecophilia* (Molin, 1858) Travassos, 1915.
Hosts: *Nycticorax nycticorax, Nyroca nyroca.*

Distribution: Europe, Africa.
Reference: 17, 103.

Family Dioctophymidae Railliet, 1915

Key to Genera of Dioctophymidae

Body without spines; head with 12-18 papillae ..... *Eustrongylides*
Body with spines; head with 6 papillae ..... *Hystrichis*

Genus *Eustrongylides* Jägerskiöld, 1909

1. *Eustrongylides mergorum* (Rudolphi, 1809).
Synonyms: *Strongylus mergorum* Rudolphi, 1809; *Strongylus papillosus* Rudolphi, 1809; *Strongylus elegans* Olifers, 1816; *Strongylus tubifex* Rudolphi, 1819; *Tropidocerca paradoxa* Linstow, 1877 not *T. paradoxa* Diesing, 1851; *Hystrichis elegans* (Olfers, 1816) Jägerskiöld, 1909; *Microtetrameres inflata* (Mehlis, 1846) Travassos, 1915 and its synonyms.
Hosts: *Alca torda, Anas boschas domestica, A. glacialis, A. mollissima, Charadrius pluvialis, Ciconia nigra, Columbus septentrionalis, Herelda glacialis, Merganser serratus, Mergus albellus, M. merganser, Numenius arquatus, Phalacrocorax carbo, Podiceps cristatus, P. minor Somateria mollissima, Uria troile.*
Distribution: Europe.
Reference: 17, 103.

2. *Eustrongylides papillosus* (Rudolphi, 1802).
Synonyms: *Strongylus papillosus* Rudolphi, 1802 part, *Eustrongylus papillisus* (Rudolphi, 1802) Diesing, 1851, part; *Hystrichis papillosus* (Rudolphi, 1802) Molin, 1861.
Hosts: *Anas boschas domestica, Anser cinereus domesticus,* and *Nuecinfraga caryocatactes.*
Distribution: Europe.
Reference: 17, 103.

3. *Eustrongylides tubifex* (Nitzsch in Rudolphi, 1819).
Synonyms: *Strongylus tubifex* Nitzsch, 1819; part; *Eustrongylus tubifex* (Nitzsch, 1819) Diesing, 1851, part; *Hystrichis tubifex* (Nitzsch, 1819) Molin, 1861, part.
Hosts: *Anas boschas domestica, Colymbus arcticus, C. septentrionalis.*
Distribution: Europe.
Reference: 17, 103.

Genus *Hystrichis* Dujardin, 1845

1. *Hystrichis coronatus* Molin, 1861.
Synonyms: *Hystrichis sp.* Molin, 1860, *H. mergi-merganensis* Diesing, 1861.
Host: *Mergus merganser.*
Distribution: Europe.
Reference: 17, 103.

2. *Hystrichis neglectus* Jägerskiöld, 1909.
Synonym: *Eustrongylus papillosus* (Rudolphi, 1802) Diesing, 1851 in part.
Hosts: *Numenius arquatus, Anas querquedulae.*
Distribution: Europe.
Reference: 17, 103.

3. *Hystichis tricolor* Dujardin, 1845.
Synonyms: *Spiroptera tricolor* (Dujardin, 1845) Diesing 1851; *Spiroptera tadornae* Bellingham, 1844.
Hosts: *Anas boschas domestica, A. b. fera, A. tadorna, T. tadorna.*
Distribution: Europe.
Reference: 17, 103.

4. *Hystrichis varispinosus* Jägerskiöld, 1909.
Host: *Mergus serrator.*
Distribution: Europe.
Reference: 17, 103.

Acanthocephala

Family Polymorphidae Meyer, 1931

Key to Genera of Polymorphidae

1. Body spines present, at least in the male 3
   No body spines present 2
2. Proboscis long and cylindrical, the proboscis containing the receptacle; with body cavity divided into individual chambers ..... *Centrorhynchus*
   Proboscis cylindrical to ovoid; receptacle inserted at base of proboscis; body cylindrical; proboscis with uniform hooks ..... *Prosthorhynchus*
3. Proboscis ovoid to barrel-shaped or cylindrical 4
   Proboscis modified; medially widened, and may have very large hooks on the ventral surface ..... *Arhythmorhynchus*
4. Body of ordinary form, with or without a shallow constriction near center of body ..... *Polymorphus*
   Anterior region of body flattened into a compressed, ventrally directed disc.... ..... *Corynosoma*

Genus *Polymorphus* Lühe, 1911

1. *Polymorphus anatis* (Schrank, 1788).
   Synonyms: *Echinorhynchus anatis* Schrank, 1788; *Ech. aleae* Gmelin, 1789; *Ech. vesiculosus* Schrank, 1790; *Ech. constructus* Zeder, 1800; *Ech. torquatus* Froelich, 1802; *Ech. filicollis* Rudolphi, 1804; *Ech. polymorphus* Bremser, 1819, in part; not Greeff, 1864; *Ech. stellaris* Molin, 1858; *Ech. leavis* v. Linstow, 1905; *Filicollis anatis* (Schrank, 1788) Luher, 1911.
   Hosts: *Anas platyrhynchos, Anser anser, Podiceps auritus, Mergus merganser, M. serrator, Somateria mollissima, Nyroca marila, N. fuligula, N. nyroca, N. ferina, Netta rufina, Bucephala clangula, Clangula hyemalis, Spatula clypeata, Oidemia fusca, O. nigra, Anas penelope, A. acuta, A. crecca, Tadorna tadorna, Cygnus olor, C. cygnus, Fulica atra, Gallinula chloropus, Porzana, Nycticorax nycticorax.*
   Distribution: Europe and Asia.
   Reference: 66, 103.
2. *Polymorphus arcticus* (Van Cleave, 1920).
   Synonyms: *Filicollis arcticus* Van Cleave, 1920; *Profilicollis arcticus* (Van Cleave, 1920).
   Host: *Erionetta (Somateria) spectabilis.*
   Distribution: North America (Canada).
   Reference: 66, 123.
3. *Polymorphus botulus* (Van Cleave, 1916).
   Synonyms: *Filicollis botulus* Van Cleave, 1916; *Profilicollis botulus* (Van Cleave, 1916).
   Hosts: *Somateria mollissima, Somateria dresseri, Anas p. platyrhynchos.*
   Distribution: North America.
   Reference: 66, 122.
4. *Polymorphus corynoides* Skrjabin, 1913.
   Host: *Anas boschas.*
   Distribution: Russia.
   Reference: 66, 93.
5. *Polymorphus magnus* Skrjabin, 1913.
   Host: *Fuligula rufina.*
   Distribution: Russia.
   Reference: 66, 93.
6. *Polymorphus marilis* Van Cleave, 1939.
   Host: *Nyroca marila.*
   Distribution: North America.
   Reference: 124.
7. *Polymorphus minutus* (Goeze, 1782).
   Synonyms: *Echinorhynchus minutus* Goeze, 1782; *Ech. boschadis* Schrank, 1788, nec Gmelin, 1790; *Ech. anatis* Gmelin, 1790, nec Schrank 1788; *Ech. collaris* Schrank,

1792; *Ech. anatis* Froelich, 1802; *Ech. versicolor* Rudolphi, 1819; *Ech. polymorphus* Bremser, 1824; *Ech. miliarius* Zenker, 1832.

Hosts: *Anas boschas fera* and *domestica*, *A. acuta*, *A. penelope*, *A. clypeata*, *A. crecca*, *Cygnus olor fera* and *domestica*, *C. musicus*, *Gallus gallus*, *Oidemia fusca*, *Gallinula chloropus*, *Nyroca fuligula*, *N. marila*, *Fuligula cristata*, *Branta bernicola*, *Squatarola squatarola*, *Rallus aquaticus*, *Somateria mollissima*, *Larus* sp., *Anas* sp., *Chaulelasmus streperus*, *Tadorna tadorna*, *Uria grylle*, *Herelda glacialis*, *Mergus serrator*, *Clangula chrysophthalmus*.

Distribution: Europe.

Reference: 66, 103.

8. *Polymorphus miniatus* (v. Linstow, 1896).

Synonym: *Echinorhynchus miniatus* v. Linstow, 1896.

Host: *Anas* sp.

Distribution: Straights of Magellan.

Reference: 66, 103.

9. *Polymorphus phippsi* Kostylew, 1922.

Synonyms: *Sipunculus lendix* Phipps, 1774; *Echinorhynchus borealis* Gmelin, 1791; *Ech. mollissimae*, Rudolphi, 1809.

Host: *Somateria mollissima*.

Distribution: Bering Straits.

Reference: 66, 103.

10. *Polymorphus striatus* (Goeze, 1782).

Synonyms: *Echinorhynchus striatus* Goeze, 1782; *Ech. ardeae* Gmelin, 1789; *Ech. mutabilis* Rudolphi, 1819.

Hosts: *Ardea cinerea*, *Herodias alba*, *Ardetta minuta*, *Boturus stellaris*, *Haliaetus albicilla*, *Nyroca ferina*, *Cygnus olor*, *Mergus serrator*.

Distribution: Europe.

Reference: 66, 103.

11. *Polymorphus* sp.

Host: *Spatula clypeata*.

Distribution: Germany.

Reference: 66.

12. *Polymorphus* sp.

Host: *Mergus cucullatus*.

Distribution: North America.

Reference: 122.

Genus *Corynosoma* Lühe, 1905

1. *Corynosoma constrictum* Van Cleave, 1918.

Host: *Oidemia americana*.

Distribution: North America.

Reference: 122.

2. *Corynosoma peposacae* (Porta, 1914).

Synonym: *Echinorhynchus peposacae* Porta, 1914.

Hosts: *Metopiana peposaca*, *Nettion brasiliense*, *Poicilonetta bahamensis*.

Distribution: Brazil and Argentina.

Reference: 66.

3. *Corynosoma strumosum* (Rudolphi, 1802).

Synonyms: *Echinorhynchus stromosus* Rudolphi, 1802; *Ech. hystrix* Bremser, 1819; *Ech. hamanni* v. Linstow, 1892; *Ech. bullosum* v. Linstow, 1892; *Ech. ventricosus* Rudolphi, 1809; *Ech. semermis* Forssell, 1904.

Hosts: *Colymbus griseigenea*, *Felis catus*, *Halichoeru grypus*, *Mergus merganser*, *M. serrator*, *Otaria jubata*, *Phalocrocorax auritus*, *P. bicristatus*, *P. carbo*, *P. graculus*, *Phoca groenlandica*, *P. hispida*, *P. vitulina*, *Phocaena phocaena*, *Putorius putorius*, *Sphemiscus demersus*, *Harelda glacialis*.

Distribution: North Sea.

Reference: 66.

Genus *Arhythmorhynchus* Lühe, 1911

1. *Arhythmorhynchus frassoni* (Molin, 1858).
   Synonyms: *Echinorhynchus frassoni* Molin, 1858; *Ech. glabicollis* Creplin, 1829.
   Hosts: *Numenius arquatus, N. tenuirostris, Mergus serrator, Larus marinus.*
   Distribution: Europe.
   Reference: 66.

Genus *Centrorhynchus* Lühe, 1911

1. *Centrorhynchus aluconis* (Müller, 1780).
   Synonyms: *Echinorhynchus aluconis* Müller, 1780; Ech. mergi (Bloch, 1782) Schrank, 1788; *Ech. inaequalis* Rudolphi, 1808; *Ech. tuba* Rudolphi, 1802; *Ech. otidis* Schank, 1788; *Ech. polyacanthoides* Creplin, 1825; *Ech. mirabilis* Polonio, 1859; *Ech. contortus* Molin, 1861; *Ech. croaticus* Stossich, 1899; *Ech. bacillaris* Zeder, 1803; *Centrosoma aluconis* Porta, 1909; *Centrorhynchus aluconis* Luhe, 1911; *Ech. tenuicaudatus* Morotel, 1899.
   Hosts: *Circus aeruginosus, Haliaetus albicilla, Mergus albellus* and others.
   Distribution: Europe.
   Reference: 66.

Genus *Prosthorhynchus* Meyer, 1931

1. *Prosthorhynchus pupa* (v. Linstow, 1905).
   Host: *Somateria spectabilis.*
   Distribution: West Taimir Peninsula.
   Reference: 66.

Part 2

Helminths of Ducks Listed According to Host[1]

Aithya ferina—see *Nyroca ferina*
Aix galericulata
  Notocotylus magniovatus
Aix sponsa
  Notocotylus urbanensis
  Heterakis caudata
Anas acuta—see *Dafila acuta*
Anas boschas—see *A. p. platyrhynchos*
Anas boschas domestica—see *A. platyrhychos* (domestic)
Anas boschas fera—see *A. p. platyrhynchos*
Anas brasiliensis—see *Nettion brasiliense*
Anas clangula—see *Glaucionetta clangula*
Anas clypeata—see *Spatula clypeata*
Anas crecca—see *Nettion crecca*
Anas discors—see *Querquedula discors*
Anas domestica—see "Ducks"
Anas fusca—see *Oidemia fusca*
Anas glacialis—see *Clangula hyemalis*
Anas hornschuchii—see *Oidemia fusca*
Anas ipecutiri—see *Nettion brasiliense*
Anas melanota—see *Sarcidiornis melanota*
Anas moschata—see *Cairina moschata* ....
Anas musica—see *Clangula hyemalis*
Anas nigra—see *Oidemia nigra*
Anas penelope—see *Mareca penelope*
Anas platyrhynchos (domestic)
  Prosthogonimus anatinus
  Prosthogonimus macrorchis
  Prosthogonimus pellucidus
  Prosthogonimus rudolphii
  Amphimerus elongatus
  Echinostoma revolutum
  Psilochasmus oxyurus
  Bilharziella polonica
  Pseudobilharziella yokagawai
  Apatemon pellucidus
  Cotylurus cornutus
  Cotylurus flabelliformis
  Parastrigea robusta
  Notocotylus aegypticus
  Notocotylus gibbus
  Zygocotyle lunatum
  Unciunia acapillicirrosa
  Hymenolepis venusta

[1] In the host list an attempt has been made to record all the names as they appear in the literature, with the correct name indicated for synonyms. In the preceding section, host names were given as they appeared in the literature. There has been no attempt to list subspecies of ducks. This is considered advisable because of the very small amount of evidence of any host-specificity among ducks, and because such a large majority of the reports do not indicate the subspecies. Geographical distribution of the worms is given in section 1.

Trichostrongylus tenuis
Epimidiostomum uncinatum
Cyathostoma bronchialis
Heterakis dispar
Heterakis gallenae
Ascaridia galli
Ascaridia lineata
Porrocaecum crassum
Echinuria uncinata
Tetrameres crami
Tetrameres fissispinus
Tetrameres gigas
Eustrongylides mergorum
Eustrongylides papillosus
Eustrongylides tubifex
Hystrichis tricolor
Polymorphus minutus

Anas platyrhynchos platyrhynchos

Plagiorchis potanini
Prosthogonimus japonicus
Prosthogonimus macrorchis
Prosthogonimus orientalis
Prosthogonimus rudolphii
Schistogonimus rarus
Opisthorchis geminus
Opisthorchis simulans
Amphimerus anatis
Amphimerus elongatus
Metorchis xanthosomus
Levinseniella pellucida
Typhlocoelum cucumerinum
Typhlocoelum cymbium
Echinostoma revolutum
Echinoparyphium recurvatum
Hydoderaeum conoideum
Psilochasmus lecithosus
Bilharziella polonica
Dendritobilharzia pulverulenta
Gigantobilharzia monocotylea
Apatemon fuligulae
Apatemon gracilis
Apatemon minor
Cotylurus cornutus
Cotylurus flabelliformis
Notocotylus attenuatus
Notocotylus scineti
Notocotylus thienemanii
Notocotylus urbanensis
Catatropis verrucosa
Paramonostomum ovatus
Zygocotyle lunatum
Ligula intestinalis
Raillietina anatina
Raillietina microcotyle
Raillietina parviuncinata
Cotugnia fastigata
Hymenolepis abortiva
Hymenolepis acicula
Hymenolepis anatina
Hymenolepis collaris
Hymenolepis compressa
Hymenolepis coronula
Hymenolepis gracilis
Hymenolepis introversa
Hymenolepis lanceolata
Hymenolepis megalops
Hymenolepis nyrocae
Hymenolepis octacantha
Hymenolepis parvula
Hymenolepis rosseteri
Hymenolepis sagitta
Hymenolepis tenuirostris
Hymenolepis trifolium
Diorchis bulbodes
Haploparaxis furcigera
Haploparaxis japonensis
Fimbriaria fasciolaris
Fimbriaria plana
Diploposthe laevis
Capillaria contorta
Trichostrongylus tenuis
Epimidiostomum uncinatum
Syngamus trachea
Heterakis dispar
Ascaridia galli
Ascaridia staphlocerca
Porrocaecum crassum
Porrocaecum ensicaudatum
Contracaecum microcephalus
Echinuria jagadornata
Streptocara crassicauda
Tetrameres crami
Tetrameres fissispinus
Hystrichis tricolor
Polymorphus anatis
Polymorphus botulus
Polymorphus corynoides
Polymorphus minutus

Anas querquedula—see *Querquedula*

Anas rubripes

Prosthogonimus anatinus
Prosthogonimus macrorchis
Prosthogonimus rudolphii
Amphimerus elongatus
Maritrema acadiae
Typhlocoelum cucumerinum
Typhlocoelum cymbium
Echinostoma revolutum
Leucochloridiomorpha macrocotyle
Cotylurus flabelliformis
Zygocotyle lunatum
Hymenolepis macrostrbilodes
Ecinuria uncinatum
Tetremeres crami

Anas sponsa—see *Aix sponsa*

Anas streperus—see *Chaulelasmus streperus*

Anas superciliosa

Echinostoma revolutum

Notocotylus attenuatus
Diorchis flavescens
Anas tadorna—see *Tadorna tadorna*
Anas torquatus—see *Histrionicus histrionicus*
Aythya australis
Diorchis flavescens
Bucephala clangula—see *Glaucionetta clangula*
Cairina moschata
Metorchis coeruleus
Ophthalmophagus magalhaesi
Echinostoma revolutum
Apatemon graciliformis
Apatemon sphaerocephalus
Zygocotyle lunatum
Biuterina longiceps
Hymenolepis bisaccata
Hymenolepis papillata
Heterakis dispar
Ascaridia galli
Porrocaecum crassum
Oxyspirura parovatum
Chaulelasmus streperus
Hymenolepis anatina
Hymenolepis fragilis
Hymenolepis gracilis
Hymenolepis octacantha
Hymenolepis teresoides
Diorchis acuminata
Diorchis spinata
Diploposthe leavis
Tetrameres crami
Polymorphus minutus
Clangula chysophthalmus—see *Glaucionetta clangula*
Clangula hyemalis
Prosthogonimus ovatus
Tocotrema concavum
Levinseniella brachysoma
Cyclocoelum arcuatum
Typhlocoelum cucumerinum
Psilostomum brevicolle
Spaeridiotrema globulus
Cyathocotyle prussica
Apatemon glacialis
Paradiplostomum ptychocheilus
Notocotylus attenuatus
Catatropis verrucosa
Paramonostomum alveatum
Schistocephalus solidus
Lateriporus teres
Choanotaenia borealis
Hymenolepis groenlandica
Hymenolepis microsoma
Fimbriaria falciformis
Fimbria fasciolaris
Capillaria anatis
Streptocara crassicauda
Eustrongylides mergorum
Polymorphus anatis
Polymorphus minutus
Corynosoma strumosum
Dafila acuta
Ophthalmophagus theodori
Typhlocoelum cymbium
Spaeridiotrema globulus
Bilharziella polonicum
Notocotylus attenuatus
Notocotylus urbanensis
Hymenolepis anatina
Hymenolepis collaris
Hymenolepis compressa
Hymenolepis megalops
Hymenolepis octacantha
Amidostomum anseris
Epimidiostomum uncinatum
Ascaridia galli
Ascaridia perspiculata
Tetrameres crami
Polymorphus anatis
"Ducks" [2]
Prosthogonimus horiuchii
Prosthogonimus leei
Prosthogonimus skrjabini
Cephalogonimus sp.
Amphimerus anatis
Metorchis intermedius
Metorchis orientalis
Metorchis tiawanensis
Maritrema rhodanicum
Philophthalmus anatinus
Philophthalmus razalensis
Cyclocoelum peudomacrostomum
Ophthalmophagus massinoi
Typhlocoelum neivai
Echinostoma elongatum
Echinostoma minor
Echinostoma pekinensis
Echinostoma revolutum
Echinoparyphium flexum
Hypoderaeum sinensis
Trichobilharzia ocellata
Notocotylus anatis
Notocotylus intestinalis
Notocotylus naviformis
Paramonostomum parvum
Paramonostomum ovatus
Raillietina cyrtus
Contracaecum microcephalum

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2 The term "Ducks" has been used for all reports in which the species of duck referred to was not clear.

Tetrameres americana
Tetrameres crami
Polymorphus minutus
Polymorphus miniatus
Erionetta spectabilis—see *Somateria spectabilis*
Erismatura jamaicensis rubida
Diorchis eccentricus
Fuligula cristata—see *Nyroca fuligula*
Fuligula fuligula—see *Nyroca fuligula*
Fuligula rufina—see *Netta rufina*
Fulix affinis—see *Nyroca affinis*
Fulix marila—see *Nyroca marila*
Glaucionetta clangula
Prosthogonimus cuneatus
Prosthogonimus rudolphii
Amphimerus elongatus
Tocotrema concavum
Spelophallus bucephalae
Spelotrema pygmaeum
Levinseniella brachysoma
Maritrema nettae
Cloacitrema ovatum
Cyclocoelum arcuatum
Echinoparyphium baculus
Stephanoprora spinosa
Psilochasmus oxyurus
Apatemon gracilis
Cotylurus flabelliformis
Notocotylus imbricata
Catatropis verrucosa
Paramonostomum bucephalae
Hymenolepis coronula
Hymenolepis macracanthos
Fimbriaria fasciolaris
Diploposthe leavis
Amidostomum anseris
Epimidiostomum orispinum
Contracaecum micropapillatum
Contracaecum spiculigerum
Streptocora crassicauda
Tetromeres crami
Polymorphus anatis
Polymorphus minutus
Herelda glacialis—see *Clangula hyemalis*
Histriornicus histriornicus
Notocotylus imbricata
Lophodytes cucullatus
Paradiplostomum ptychocheilus
Polymorphus sp.
Mareca americana
Amphimerus elongatus
Echinostoma revolutum
Cotylurus flabelliformis
Zygocotyle lunatum
Tetrameres crami
Mareca penelope
Opisthorchis simulans
Echinostoma revolutum
Notocotylus attenuatus
Hymenolepis collaris
Hymenolepis compressa
Hymenolepis coronula
Hymenolepis fallax
Hymenolepis fasciculata
Hymenolepis gracilis
Hymenolepis microsoma
Diorchis acuminata
Fimbriaria fasciolaris
Amidostomum anseris
Epimidiostomum orispinum
Epimidiostomum uncinatum
Echinuria uncinatum
Polymorphus anatis
Polymorphus minutus
Marila affinis—see *Nyroca affinis*
Marila marila—see *Nyroca marila*
Melanitta deglandi
Orchipedum tracheicola
Himasthala incisa
Yseria californica
Melanitta perspiculata
Fimbriaria falciformis
Merganser castor—see *Mergus Merganser*
Merganser rubricollis—see *Mergus merganser*
Mergellus albellus
Cyclocoelum arcuatum
Typhlocoelum cucumerinum
Echinoparyphium baculus
Apatemon gracilis
Cotylurus erraticum
Hymenolepis tenuirostris
Eustrongylides mergorum
Centrorhynchus aluconis
Mergus albellus—see *Mergellus albellus*
Mergus americana—see *Mergus merganser*
Mergus merganser
Metorchis tener
Tocotrema concavum
Stephanoprora mergi
Hypoderaeum conoideum
Sphaeridiotrema globulus
Apatemon gracilis
Paradiplostomum ptychocheilus
Neodiplostomum orientale
Notocotylus attenuatus
Diphyllobothrium ditermus
Ligula intestinalis
Schistocephalus solidus
Hymenolepis anceps
Hymenolepis gracilis
Hymenolepis tenuirostris
Hymenolepis tritesticulata
Hymenofimbria merganseri

Fimbriaria fasciolaris
Capillaria anatis
Contracaecum spiculigerum
Contracaecum turkestanicum
Streptocara crassicaudata
Tetrameres fissispina
Eustrongylides mergorum
Hystrichis coronatus
Polymorphus anatis
Corynosoma strumosum

Mergus serrator
Prosthogonimus rudolphii
Metorchis crassiusculus
Metorchis xanthosomus
Tocotrema concavum
Typhlocoelum cucumerinum
Echinochasmus sp.
Sphaeridiotrema globulus
Apatemon gracilis
Paradiplostomum ptychocheilus
Catatropis verrucosa
Diphyllobothrium ditermus
Ligula intestinalis
Schistocephalus solidus
Ophryocotyle insignis
Hymenolepis gracilis
Hymenolepis tenuirostris
Diorchis parviceps
Fimbriaria fasciolaris
Cosmocephalus obvelatus
Streptocara crassicanda
Eustrongylides mergorum
Hystrichis varispinosus
Polymorphus anatis
Polymorphus minutus
Polymorphus striatus
Corynosoma strumosum
Arhythmorhynchus frassoni

Netta rufina
Hymenolepis lanceolata
Hymenolepis rarus
Fimbriaria fasciolaris
Diploposthe laevis
Polymorphus anatis
Polymorphus magnus

Nettion brasilense
Echinostoma revolutum
Zygocotyle lunatum
Corynosoma peposacae

Nettion carolinense
Echinostoma revolutum
Cotylurus flabelliformis
Echinuria uncinatum
Tetrameres crami

Nettion castaneum
Diorchis flavescens

Nettion crecca
Prosthogonimus cuneatus
Bilharziella polonica
Notocotylus attenuatus
Notocotylus thienemanni
Hymenolepis fragilis
Hymenolepis gracilis
Hymenolepis megalops
Hymenolepis octacantha
Hymenolepis trichorhyncha
Diorchis acuminata
Haploparaxis furcigera
Fimbriaria fasciolaris
Diploposthe laevis
Capillaria contorta
Amidostomum acutum
Amidostomum anseris
Epomidiostomum orispinum
Epomidiostomum querquedulae
Polymorphus anatis
Polymorphus minutus

Nettion delicata
Zygocotyle lunatum

Nettion formosum
Apatemon minor

Nyroca affinis
Prosthogonimus rudolphii
Amphimerus elongatus
Maritrema nettae
Levinseniella minuta
Typhlocoelum cymbium
Sphaeridiotrema globulus
Microbilharzia chapini
Cotylurus flabelliformis
Zygocotyle lunatum
Tetrameres crami

Nyroca americana
Amphimerus elongatus
Typhlocoelum cucumerinum
Cotylurus flabelliformis
Zygocotyle lunatum
Hymenolepis hamulacanthos

Nyroca clangula—see *Glaucionetta clangula*

Nyroca collaris
Prosthogonimus rudolphii
Cotylurus flabelliformis

Nyroca ferina
Prosthogonimus ovatus
Philophthalmus nyrocae
Cyclocoelum arcuatum
Apatemon gracilis
Notocotylus attenuatus
Hymenolepis compressa
Hymenolepis lanceolata
Hymenolepis setigera
Haploparaxis furcigera
Diploposthe laevis
Capillaria spinulosa

Tetrameres fissispina
Polymorphus anatis
Polymorphus striatus

Nyroca fuligula
Opisthorchis simulans
Levinseniella pellucida
Cyclocoelum arcuatum
Ophthalmophagus robustus
Typhlocoelum cucumerinum
Eucotyle zakharowi
Echinostoma revolutum
Echinoparyphium recuvatum
Psilochasmus oxyurus
Sphaeridiotrema globulus
Bilharziella polonica
Apatemon fuligulae
Notocotylus attenuatus
Hymenolepis collaris
Hymenolepis compressa
Hymenolepis kowalewski
Hymenolepis megalops
Hymenolepis nitidulans
Hymenolepis tenuirostris
Diorchis nyrocae
Haploparaxis fuligulosa
Diplopostlhe leavis
Amidostomum acutum
Amidostomum anseris
Epomidiostomum orispinum
Polymorphus anatis
Polymorphus minutus

Nyroca hyemalis—see *Clangula hyemalis*
Nyroca leucophthalmus—see *Nyroca nyroca*

Nyroca marila
Prosthogonimus ovatus
Tocotrema concavum
Typhlocoelum cucumerinum
Echinostoma revolutum
Echinoparyphium baculus
Echinoparyphium recurvatum
Acanthoparyphium marilae
Hypodereum conoideum
Psilochasmus oxyurus
Spaeridiotrema globulus
Cotylurus cornutus
Cotylurus flabelliformis
Paromonostomum alveatum
Schistocephalus solidus
Hymenolepis aequabilis
Hymenolepis arcuata
Hymenolepis compressa
Hymenolepis coronula
Hymenolepis fallax
Hymenolepis gracilis
Hymenolepis megalops
Hymenolepis microsoma
Hymenolepis nyrocae
Hymenolepis pigmentata
Hymenolepis tenerrina
Hymenolepis tenuirostris
Fimbriaria fasciolaris
Diplopostlhe leavis
Amidostomum ansaris
Tetrameres crami
Polymorphus anatis
Polymorphus marilis
Polymorphus minutus

Nyroca nyroca
Psilotrema simillimum
Psilotrema spiculigerum
Bilharziella polonica
Hymenolepis solowiowi
Haploparaxis elisae
Diplopostlhe leavis
Tetrameres gynaecophila
Polymorphus anatis

Nyroca valisineria
Amphimerus elongatus
Cotylurus flabelliformis

Oidemia americana
Corynosoma constrictum

Oidemia deglandi—see *Melanitta deglandi*

Oidemia fusca
Tocotrema concavum
Orchipedum tracheicola
Gymnophallus bursicola
Gymnophallus dipsilis
Cyclocoelum arcuatum
Typhlocoelum cucumerinum
Echinoparyphium baculus
Cyathocotyle melanittae
Apatemon fuligulae
Apatemon gracilis
Notocotylus attenuatus
Paramonostomum alveatum
Latiporus biuterinus
Hymenolepis microsoma
Hymenolepis tenuirostris
Fimbriaria fasciolaris
Capillaria anatis
Amidostomum acutum
Amidostomum anseris
Epomidiostomum orispinum
Streptocara crassicauda
Polymorphus anatis
Polymorphus minutus

Oidemia nigra
Metorchis xanthosomus
Spelotrema pygmaeum
Levinseniella brachysoma
Gymnophallus affinis
Gymnophallus dipsilis
Gymnophallus macroporus
Gymnophallus oidemiae
Gymnophallus ovoplenus

Cyclocoelum arcuatum
Echinostoma revolutum
Psilostomum brevicolle
Psilochasmus oxyurus
Apatemon gracilis
Catatropis verrucosa
Hymenolepis micrancristrota
Hymenolepis microsoma
Diploposthe laevis
Amidostomum acutum
Amidostomum anseris
Amidostomum monodon
Epomidiostomum orispinum
Epomidiostomum uncinatum
Polymorphus anatis

Paecilionetta bahamensis
Amphimerus elongatus
Levinseniella cruzi
Maritrema nicolli
Psilochasmus agilis
Corynosoma peposacae

Querquedula discors
Eucotyle wheri
Echinostoma revolutum
Pseudobilharziella querquedulae
Trichobilharzia ocellata
Cotylurus flabelliformis
Zygocotyle lunatum
Hymenolepis querquedulae
Tetrameres crami

Querquedula querquedula
Prosthogonimus querquedulae
Metorchis crassiusculus
Metorchis xanthosomus
Hypoderaeum conoideum
Bilharziella polonica
Dendritobilharzia pulverulenta
Notocotylus attenuatus
Notocotylus scineti
Hymenolepis fallax
Diorchis kodonoides
Diorchis microcirrosa
Fimbriaria fasciolaris
Diploposthe laevis
Capillaria anatis
Amidostomum anseris
Hystrichis neglectus

Sarcidiornis melanonota
Zygocotyle lunatum

Somateria dresseri—see *Somateria mollissima*

Somateria mollissima
Spelophallus primus
Spelotrema pygmaeum
Gymnophallus bursicola
Gymnophallus choledocus
Gymnophallus somateriae
Cyclocoelum arcuatum
Typhlocoelum cucumerinum
Notocotylus attenuatus
Catatropis verrucosa
Paramonostomum alveatum
Tetrabothrius arcticus
Lateriporus teres
Hymenolepis fallax
Hymenolepis microsoma
Fimbriaria fasciolaris
Amidostomum acutum
Amidostomum anseris
Epomidiostomum orispinum
Eustrongylides mergorum
Polymorphus anatis
Polymorphus botulus
Polymorphus minutus
Polymorphus phippsi

Somateria spectabilis
Polymorphus arcticus
Prosthorhynchus pupa

Spatula clypeata
Prosthogonimus ovatus
Typhlocoelum cymbium
Echinoparyphium baculus
Hypoderaeum conoideum
Cotylurus flabelliformis
Notocotylus attenuatus
Notocotylus imbricata
Hymenolepis anatina
Hymenolepis echinocotyle
Hymenolepis gracilis
Hymenolepis octacantha
Diploposthe laevis
Tetrameres crami
Polymorphus anatis
Polymorphus minutus
Polymorphus sp.

Spatula rhynchotis
Diorchis flavescens

Tadorna radjah
Hymenolepis lamellata

Tadorna tadorna
Gymnophallus choledocus
Echinostoma revolutum
Psilochasmus oxyurus
Notocotylus attenuatus
Hymenolepis coronula
Hymenolepis gracilis
Cyathostoma tadornae
Heterakis dispar
Heterakis gallinae
Streptocara crassicauda
Hystrichis tricolor
Polymorphus anatis
Polymorphus minutus

REFERENCES

1. ALVEY, C. H. 1932—A species of *Cephalogonimus* from the domestic duck. Jour. Parasitol. **19**:174.
2. BACZYNSKA, HELENE. 1914—Etudes anatomique et histologiques sur quelques nouvelles especes de Cestodes d'oiseaux. Bull. Soc. Neuchat. Sci. **40**:187-239.
3. BARKER, F. D. 1911—The trematode genus *Opisthorchis*. Arch. d. parasit. **14**:513-561.
4. BAYLIS, H. A. 1928—A Manual of Helminthology. London.
5. BEAUDETTE, F. R. 1939—Flukes in the respiratory tract of ducks. Jour. Am. Vet. Med. Soc. N. S. **47**:44.
6. BEAVER, P. C. 1937—Experimental studies on *Echinostoma revolutum* (Froelich), a fluke of birds and mammals. Ill. Biol. Monogr. **15**(1):1-96.
7. BRANDES, G. 1892—Revision des Monostomiden. Zbl. f. Bakter. I. O. **12**: 504-511.
8. BRAUN, M. 1901—Trematoden der Bursa Fabricii, des Eileiters und der Eier der Vögel. Zbl. f. Bakter. I. O. **29**:12-19.
9. ———1901—Zur Revision der Trematoden der Vögel. Zbl. f. Bakter. I. O. **29**: (in three parts).
10. ———1902—Fascioliden der Vögel. Zool. Jb. Syst. **16**:1-163.
11. BRUMPT, E. 1931—*Cercaria ocellata*, determinant la dermatite des nageurs provient d'une bilharzie des canards. Com. rend. d. sc. d. l'acad. d. sci. **193**:612.
12. CANNON, D. G. 1938—Some trematode parasites of ducks and geese in eastern Canada. Can. Jour. Res., Sec. D., **16**(9):268-280.
13. CARRERE, P. 1936—Sur le cycle evolutif d'un *Maritrema* (trematodes). Comp. rend. d. l'acad. d. sci. **202**:244.
14. CHEATUM, E. L. 1938—*Tanasia pelidinae* n. sp. and *Orchipedum tracheicola* (Trematoda). Jour. Parasitol. **24**(2):135-141.
15. CLERC, W. 1907—Notes sur les cestodes d'oiseaux de l'Oural. Zbl. f. Bakter. L. O. **42**:(in three parts).
16. COHN, L. 1900—Zur Anatomie der Vogelcestoden. Zeit. wiss. Zool. **67**(2): 255-290.
17. CRAM, E. B. 1927—Bird parasites of the nematode suborders Strongylata, Ascaridata, and Spirurata. U. S. Nat. Mus. Bull. **140**:1-465.
18. ——— AND E. CUVILLIER. 1934—Observations on *Trichostrongylus tenuis* infestation in domestic and game birds in the United States. Parasitol. **26**(2): 340-346.
19. ——— AND E. E. WEHR. 1934—The status of the species of *Trichostrongylus* of birds. Parasitol. **26**(2):335-340.
20. DIETZ, E. 1910—Die Echinostomiden der Vögel. Zool. Jb. Suppl. **12**:265-512.
21. EJSMONT, L. 1929—Über zwei Schistosomatidengattungen der Vögel. Bull. Acad. Polonaise Sci. et Let., Ser. B., 389-403.
22. ———1931—Über die Identität von *Proshystera rossitensis* Korkhaus und *Tanaisia fedtschenkoi* Skrjabin, nebst einigen Bemerkungen uber Trematoden mit verbundenen Darmschenkeln. Bull. Acad. Polonaise Sci. et Let., Ser. B., **2**:531-547.
23. ESSEX, H. E. 1932—A new larval cestode, probably *Hymenolepis cuneata*, a tapeworm of wild ducks. Jour. Parasitol. **18**(4):291-294.
24. FUHRMANN, O. 1906. Die *Hymenolepis*-Arten der Vögel. Zbl. f. Bakter. I. O. **41**:352-358, 440-452; **42**:620-628, 730-755.

25. ———1907—Bekannte und neue Arten und Genera von Vogeltänien. Zbl. f. Bakter. I.O. **45**:516-536.
26. ———1908—Die Cestoden der Vögel. Zool. Jb. Suppl. **10**:1-232.
27. ———1908—Das Genus *Anonchotaenia* und *Buiterina*. II. Das Genus *Buiterina* Fuhrmann. Zbl. f. Bakter. **48**:412-428.
28. ———1924—*Hymenolepis macrocanthos*, considerations sur le genera *Hymenolepis*. Jour. Parasitol. **11**(1):33-44.
29. ———1928—Trematoda und Cestoda. In Kükenthal's Handbuch der Zoologie **2**, Teil 1 und 2.
30. Gower, W. Carl. 1938—Studies on the trematode parasites of ducks in Michigan with special reference to the mallard. Ag. Exp. Station, Mich. St. Col., Memoir **3**, 1-94.
31. ———1938—Seasonal abundance of some parasites of wild ducks. Jour. Wildlife Manag. **2**(4):223-232.
32. Harrah, E. C. 1922—North American Monostomes. Ill. Biol. Monogr. **12**(3): 1-106.
33. Heinemann, E. 1937—Über den Entwicklungskreislauf der Trematodengattung *Metorchis* sowie Bemerkungen zur Systematik dieser Gattung. Zeit. f. Parasitenkde **9**(2):237-260.
34. Hsü, Y. C. 1935—Trematodes of fowls in Soochow. Peking Nat. Hist. Bull. **10**:141-150.
35. Hsü, H. F. and C. Y. Chow. 1938—Studies on the helminths of fowls. I. On the second intermediate hosts of *Metorchis orientalis* and *M. taiwanensis*, liver flukes from ducks. Chinese Med. Jour. Suppl. **2**:433-440.
36. Jameson, H. L. and W. Nicoll. 1913—On some parasites of the scoter duck *(Oidemia nigra)* and their relation to the pearl inducing trematodes in the edible mussel *(Mytilus edulis)*. Proc. Zool. Soc. London **12**:53-63.
37. Jägerskiöld, L. A. 1900—*Levinsenia pygmaea* Levinsen, ein genitalnapftragendes Distomum. Zbl. f. Bakter. I. O. **27**:732-740.
38. ———1908—Kleine Beiträge zur Kenntnis der Vogeltrematoden. Zbl. f. Bakter. I. O. **48**:302-317.
39. Johnson, J. C. 1920—The life cycle of *Echinostoma revolutum* (Froelich). Uni. Cal. Pub. Zool. **19**(11):335-388.
40. Joyeaux, C. 1922—Recerches sur le Tenias des Anseriformes. Bull. Soc. Path. Exot. **15**:46-57.
41. ——— and J. G. Bear. 1927—Note sur les Cyclocoelidae. Bull. Soc. Zool. France **52**:426-434.
42. Kalmbach, E. R. and D. R. Coburn. 1937—Disease factors in reported cases of starvation in waterfowl. Trans. N. Am. Wildlife Conf.: 404-410.
43. Kossack, W. 1911—Über Monostomiden. Zool. Jb. Syst. **31**:493-590.
44. Kotlan, A. and W. L. Chandler. 1925—A newly recognized disease (Prosthogonimiasis) of fowls in the United States. Jour. Am. Vet. Med. Assn. N. S. **67**:756-763.
45. Ku, Chang-Tung. 1937—Two new trematodes of the genus *Notocotylus*, with a key to the species of the genus. Peking Nat. Hist. Bull. **12**(2):113-122.
46. ———1937—On a new trematode parasite from the Peking area. Peking Nat. Hist. Bull. **12**(1):39-41.
47. v. Linstow, A. 1904—Neue Helminthen aus Westafrika. Zbl. f. Bakter. I. O. **36**:379-383.
48. Linton, E. 1892—Notes on avian entozoa. Proc. U. S. Nat. Mus. **15**:87-113.
49. ———1927—Notes on cestode parasites of birds. Proc. U. S. Nat. Mus. **70**(7):1-73.

50. ———1928—Notes on trematode parasites of birds. Proc. U. S. Nat. Mus. **73**(1):1-36.

51. Looss, A. 1899—Weitere Beiträge zur Kenntniss der Trematoden-Fauna Aegyptens, zugleich Versuch einer natürlichen Gliederung des Genus Distomum Retzius. Zool. Jb. Syst. **12**:521-784.

52. Lühe, M. 1909—Parasitiche Plattwürmer. I: Trematoda. In Süsswasserfauna Deutschlands, Heft **17**.

53. ———1910—Parasitische Plattwürmer. II: Cestoda. In Süsswasserfauna Deutschlands, Heft **18**.

54. ———1911—Acanthocephalen. In Süsswasserfauna Deutschlands, Heft **16**.

55. Luttermoser, G. W. 1935—A note on the life history of the monostome *Notocotylus urbanensis*. Jour. Parasitol. **21**(6):456.

56. Lutz, A. 1924—Untersuchung über die Entwicklungsgeschichte brasilianischer Trematoden. Spezieller Teil. I. Echinostomidae. Mem. Inst. Oswaldo Cruz **17**:75-93.

57. Macy, R. W. 1934—Prosthogonimus macrorchis n. sp., the common oviduct fluke of domestic fowls in the northern United States. Trans. Am. Micr. Soc. **53**(1):30-34.

58. Macy, R. W. 1934—Studies on the taxonomy, morphology, and biology of *Prosthogonimus macrorchis* Macy, a common oviduct fluke of domestic fowls in North America. Ag. Exp. St., Uni. Minn. Tech. Bull. **98**:1-71.

59. Manter, H. W. and O. L. Williams. 1928—Some monostomes from North American birds. Trans. Am. Micr. Soc. **47**:90-93.

60. Mayhew, R. L. 1925—Studies on the avian species of the cestode family Hymenolepididae. Ill. Biol. Monogr. **10**(1):1-125.

61. ———1929—The genus, *Diorchis*, with descriptions of four new species from North America. Jour. Parasitol. **15**(4):251-259.

62. McCoy, O. R. 1928—Life history studies on trematodes from Missouri. Jour. Parasitol. **14**:209-228.

63. McLeod, J. A. 1937—Two new schistosomid trematodes from water birds. Jour. Parasitol. **23**(5):458-466.

64. Meggitt, F. J. 1920—A contribution to our knowledge of tapeworms of poultry. Parasitol. **12**(3):301-310.

65. ——— and Maung Po Saw. 1924—On a new tapeworm from the duck. Ann. Mag. Nat. Hist. **14**:324-326.

66. Meyer, A. 1932-33—Acanthocephala. Bronn's Klassen u. Ordungen des Tierreichs. Leipzig.

67. Moghe, M. A. 1933—Four new species of avian cestodes from India. Parasitol. **25**(3):333-341.

68. Morgan, D. O. 1927—Studies on the family Opisthorchiidae Braun, 1901, with a description of a new species from a sarus crane *(Antigone antigone)*. Jour. Helminth. **5**:89-104.

69. Morishita, K. 1929—Some avian trematodes from Japan especially Formosa, with a reference list of all known Japanese species. Annot. Soc. Zool. Japan **12**:143-173.

70. Mühling, P. 1896—Beiträge zur Kenntnis der Trematoden. Arch. f. Naturg. **62**(1):244-279.

71. ———1898—Die Helminthfauna der Wirbeltiere Oestpreussens. Arch. f. Naturg. **64**(1):1-118.

72. Nicoll, W. 1906—Some new and little known trematodes. Ann. Mag. Nat. Hist. ser. 7, **17**:523.

73. ———1907—Observations on trematode parasites in British birds. Ann. Mag. Nat. Hist. ser. 7, **20**:245-271.

74. ———1914—The trematode parasites of North Queensland. II. Parasites of birds. Parasitol. **7**(2):105-127.
75. ———1923—A reference list of the trematode parasites of British birds. Parasitol. **15**:236-252.
76. Odhner, Th. 1900—*Gymnophallus*, eine neue Gattung von Vogeldistomum. Zbl. f. Bakter. I. O. **28**:12-23.
77. ———1905—Die Trematoden des Arktischen Gebietes. Fauna Arctica **4**:291-372.
78. ———1911-1913—Zum natürlichen System der digenetischen Trematoden. Zool. Anz. **37, 38, 41, 42,** (parts 1-6).
79. Poche, F. 1925—Das System der Platodaria. Arch. f. Naturg. **91**:1-485.
80. Price, E. W. 1928—The host relationships of the trematode genus *Zygocotyle*. Jour. Ag. Res. **36**(10):911-914.
81. ———1929—A synopsis of the trematode family Schistosomidae with descriptions of new genera and species. Proc. U. S. Nat. Mus. **75**(18):1-39.
82. ———1930—Two new species of trematode worms of the Genus *Eucotyle* from North American birds. Proc. U. S. Nat. Mus. **77**(1):1-4.
83. ———1934—New trematodes of birds. Smith. Misc. Col. **91**(6):1-6.
84. ———1934—Losses among wild ducks due to infestation with *Sphaeridiotrema globulus* (Rudolphi). Proc. Hel. Soc. Wash. **1**(2):31-33.
85. Railliet, A. 1921—Les Cestodes des oiseaux domestiques. Rec. Med. Vet. **97**:185-205.
86. Ransom, B. H. 1902—On *Hymenolepis carioca* and *H. megalops*, with remarks on the classification of the group. Trans. Am. Micr. Soc. **23**:151-172.
87. ———1909—The Taenoid cestodes of North American birds. U. S. Nat. Mus. Bull. **69**:1-140.
88. ———1920—Synopsis of the trematode family Heterophyidae with descriptions of a new genus and five new species. Proc. U. S. Nat. Mus. **57**:527-573.
89. Schofield, F. M. 1932—Heavy mortality among ducklings due to *Hymenolepis coronula*. Ann. Rept. Ont. Vet. Col. **1931**:49.
90. Shen, Tseng. 1931—Touve trouvee dans un oeuf de poule a Nankin et considerations sur le especes du genre *Prosthogonimus*. Bull. Soc. Zool. France **56**:468-478.
91. Skrjabin, K. I. 1913—Traceophilus sisowi n. g., n. sp. Zbl. f. Bakter. I. O. **69**:90-94.
92. ———1913—Vogeltrematoden aus Russisch-Turkestan. Zool. Jb. Syst. **35**: 351-388.
93. ———1913—Zur Acanthocephalen-Fauna Russisch-Turkestans. a. Acanthocephalen der Sumpf- und Wasservögel. Zool. Jb. Syst. **35**:403-414.
94. ———1914—Vogel-Cestoden aus Russisch-Turkestan. Zool. Jb. Syst. **37**:411-492.
95. ———1914—Zwei Vogelcestoden mit gleicher Scolex-bewaffnung und verschiedener Organisation (*Hymenolepis collaria* Batsch und *Hymenolepis compressa* Linton). Zbl. f. Bakter. I. O. **74**:275-278.
96. ———1915—Beitrage zur Kenntnis einiger Vogelcestoden. Zbl. f. Bakter. I. O **75**:59-83.
97. ———1924—Nierentrematoden der Vögel Russlands. Zbl. f. Bakter. II. **62**:80-90.
98. ———1928—Sur la faune des trematodes des oiseaux de Transbaikalie Ann. Parasitol. Hum. Comp. **6**:80-87.
99. ——— and W. P. Baskakow. 1925—Über die Trematodengattung Prosthogonimus (Versuch einer Monographie). Zeit. Inf. Parasit. Krank. u. Hyg. Haust. **28**:195-212.
100. Spreihn, E. E. W. 1932—Lehrbuch der Helminthologie. Berlin.
101. Stiles, C. W. and A. Hassall. 1908—Index-catalogue of medical and veterinary

zoology. Subjects: Trematoda and Trematode Diseases. Hyg. Lab. Bull. **37**:1-401.

102. ———1912—Index-catalogue of medical and veterinary zoology. Subjects: Cestoda and Cestodaria. Hyg. Lab. Bull. **85**:1-467.

103. ———1920—Index-catalogue of medical and veterinary zoology. Subjects: Nematoda, Gordiacea, and Acanthocephali. Hyg. Lab. Bull. **114**:1-881.

104. STILES, C. W. AND ORLEMAN. 1926—Des genres de cestodes *Raillietina, Ransomia,* et *Johnstonia.* Ann. de parasitol. Hum. comp. **4**:65.

105. STOSSICH, M. 1902—Il *Monostomum mutabile* Zeder e le sue forme affine. Boll. Soc. adriat. sci. nat. Trieste **21**:1-40.

106. STUNKARD, H. W. 1917—Studies on North American Polystomidae, Aspidogatridae, and Paramphistomidae. Ill. Biol. Monogr. **3**(3):1-114.

107. ———1934—The life cycle of *Typhlocoelum cymbium* (Diesing, 1850) Bull. Soc. Zool. France. **59**:447-466.

108. ——— AND F. W. DUNIHUE. 1931—Notes on the trematodes from a Long Island duck with description of a new species. Biol. Bull. **60**:179-186.

109. SWALES, W. E. 1933—*Streptovitella acadiae* gen. et sp. nov., a trematode of the family Heterophyidae from the black duck *(Anas rubripes).* Jour. Helminth. **11**:115-118.

110. ———1933—Tetrameres crami sp. nov., a nematode parasitizing the proventriculus of a domestic duck in Canada. Can. Jour. Res. Sec. D. **8**:334-336.

111. ———1933—A review of Canadian Helminthology. Parts I and II. Can. Jour. Res. Sec. D. **8**:468-482.

112. ———1936—*Tetrameres crami* Swales, 1933, a nematode parasite of ducks in Canada. Morphological and biological studies. Can. Jour. Res. Sec. D. **14**:151-164.

113. SZIDAT, L. 1928—Studien an einigen selten en Parasiten der Kurischen Nehrung. Zeit. Parasitenkde. **1**:331-334.

114. ———1929—Beiträge zur Kenntnis der Gattung Strigea. Zeit. Parasitenkde. **1**:612-764.

115. ———1929—Zur Entwicklungsgeschichte des Bluttrematoden der Enten, *Bilharziella polonica.* Zbl. f. Bakter. I. O. **111**:461-470.

116. ———1930—*Gigantobilharzia monocotylea* n. sp., ein neuer Blutparasit aus ostpreussischen Wasservögeln. Zeit. Parasitenkde. **2**:583-588.

117. ———1937—Über die Entwicklungsgeschichte von *Sphaeridiotrema globulus* Rud., 1814, und die Stellung der Psilostomidae Odhner im natürlichen System. I. Entwicklungsgeschichte von *Sphaeridiotrema globulus* Rud. Zeit. Parasitenkde. **9**:529-543.

118. SZIDAT, L. AND U. SZIDAT. 1933—Beiträgezur Kenntnis der Trematoden der Monostomidengattung *Notocotylus* Dies. Zbl. f. Bakter. I. O. **129**:411-422.

119. SZIDAT, U. 1935—Weitere Beiträge zur Kenntnis der Trematoden der Monostomidengattung *Notocotylus* Diesing Zbl. f. Bakter. I. O. **133**:265-270.

120. TABANGI, M. A. 1928—Trematode parasites of Philippine vertebrates. Phil. Jour. Sci. **36**:351-369.

121. VAN CLEAVE, H. J. 1916—Acanthocephala of the genus *Centrorhynchus* and *Mediorhynchus* (n. g.) from North American birds. Trans. Am. Micr. Soc. **35**:221-232.

122. ———1918—The Acanthocephala of North American birds. Trans. Am. Micr. Soc. **37**:19-47.

123. ———1920—Acanthocephala of the Canadian Arctic Expedition. Rept. Can. Arc. Exp. **9**(part E).

124. ———1939—A new species of the Acanthocephalan genus *Polymorphus* and notes on the status of the name *Profilicollis.* Jour. Parasitol. **25**:129-130.

125. Van Haitsma, J. P. 1930—Studies on the trematode family Strigeidae (Holostomidae) XXII. *Cotylurus flabelliformis* (Faust) and its life history. Mich. Acad. Sci. Trans. **13**:447-483.

126. ———1930—Studies on the trematode family Strigeidae (Holostomidae) XX. *Paradiplostomum ptychocheilus* (Faust). Trans. Am. Micr. Soc. **49**: 140-153.

127. Vevers, G. M. 1923—Observations on the life history of *Hyderaeum conoideum* (Bloch) and *Echinostoma revolutum* (Froelich), trematode parasites of the domestic duck. Ann. Apl. Bio. **10**:134-136.

128. Viana, L. 1924—Tenativa de catalogacae das especies brazileiras de trematodeos. Mem. Inst. Oswaldo Cruz. **17**:95-227.

129. Witenberg, G. 1926—Die Trematoden der Familie Cyclocoelidae Kossack, 1911. Zool. Jb. Syst. **52**:103-186.

130. ———1928—Notes on Cyclocoelidae. Ann. Mag. Nat. Hist. **9**:410-447.

131. ———1929—Studies on the trematode family Heterophyidae. Ann. Trop. Med. Parasitol. **33**:131-239.

132. ———1930—Corrections to my paper "Studies on the trematode family Heterophyidae." Ann. Mag. Nat. Hist., ser. 8, **5**:412-414.

133. Woodland, W. N. F. 1930—On three new cestodes from birds. Parasitol. **22**: 214-229.

134. Yamaguti, S. 1933—Studies on the helminth fauna of Japan. I. Trematodes of birds, reptiles, and mammals. Jap. Jour. Zool. **5**:1-133.

135. ———1934—Studies on the helminth fauna of Japan. III. Trematodes of birds II. Jap. Jour. Zool. **5**:543-582.

136. ———1935—Studies on the helminth fauna of Japan. V. Trematodes of birds III. Jap. Jour. Zool. **6**:159-183.

137. ———1935—Studies on the helminth fauna of Japan. VI. Cestodes of birds I. Jap. Jour. Zool. **6**:183-233.

138. ———1935—Studies on the helminth fauna of Japan VIII. Acanthocephala I. Jap. Jour. Zool. **6**:247-279.

139. ———1935—Studies on the helminth fauna of Japan XII. Avian Nematodes. Jap. Jour. Zool. **6**:403-433.

140. Yorke, W. and P. A. Mapelstone. 1926—The Nematode Parasites of Vertebrates. Philadelphia.

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North American Rhabdocoela and Alloeocoela. V. Two New Mesostomine Rhabdocoels

Libbie H. Hyman

The finding of new species of rhabdocoels in every collection sent for examination emphasizes anew the paucity of our knowledge of this group in North America and the great need for intensive study of small fresh-water invertebrates. The two new species here described are again mesostomine typhloplanids.

Mesostoma macroprostatum, sp. nov.

Material.—Several specimens sent by Dr. I. H. Blake, University of Nebraska, and three specimens originating from Dr. Blake sent by the U. S. National Museum.

External characters.—Elongate, anterior end narrowed, posterior end rounded (Fig. 1), 2.0-2.5 mm. long, very dark brown and opaque, with two elongated eyes. Cross-section rectangular (Fig. 2), anterior end apparently with slightly incurved sides but this may be the result of fixation.

General anatomy.—Because of poor histological condition of the material, not much detail can be given of the structure. Digestive tract typically mesostomine, typical rosette pharynx anterior to the middle of the body; main excretory tubules open into the pharyngeal cavity. Eyes do not appear very typical on whole mount, but sections show them to have usual structure. Body clothed in a typical cellular ciliated epithelium (Fig. 2), which contains brown pigment, especially ventrally. The pigmentation is peculiar in that it is much denser ventrally than dorsally. Parenchyma adjacent to the epithelium also contains much pigment, especially ventrally. Rhabdite tracts are wanting.

Reproductive system.—In its general plan and arrangement, the reproductive system follows that characteristic of the genus but several peculiarities exist. No testes could be found in any of several specimens sectioned and this made allocation of the specimens to a genus very difficult as the subdivision of the Typhloplanidae into subfamilies is based on the location of the testes. It was finally concluded that the specimens must have been collected at the close of their breeding season and that the testes had degenerated; this conclusion was borne out by the state of collapse of the seminal receptacle and copulatory bursa and the complete absence of sperm in them in all specimens. Even the seminal vesicle contains only a trace of sperm. It is then to be presumed that the testes are dorsal as in other Mesostominae.

Yolk glands numerous, in lateral body regions (Fig. 2) as characteristic of the genus. Copulatory complex behind the pharynx with separate genital

pore (Fig. 1). General arrangement of complex as usual in the genus, female canal to right, male to left, copulatory bursa between them. General view of the copulatory complex in Fig. 3, shown from behind looking forward, copulatory bursa not well seen. Female canal characteristic of the genus, but somewhat muscular, muscular coat extending along the oviduct to the ovary; seminal receptacle collapsed with thick folded wall. Yolk duct not found. Copulatory bursa enters genital atrium behind and lateral to the entrance of the female canal (Fig. 4). Male canal remarkable, not typical of the genus. There is a small rounded seminal vesicle (Fig. 3) containing only a trace of sperm. From this the enormous oval prostatic vesicle extends dorsally; cluster of prostate glands enters ventral end of vesicle, alongside entrance of seminal vesicle. Wall of prostatic vesicle appears thick and hard but is probably composed of lengthwise muscle fibers; interior made up of usual gland outlets containing coarse eosinophilous granules. Penis papilla very large, conical, distinct from prostatic vesicle, projecting into male canal. Valve occurs at junction of prostatic vesicle and penis papilla. Wall of penis papilla thick and muscular; lumen lacks a cuticularized lining. Male canal elongated, tubular, entering dorsal wall of genital atrium anterior to opening of female canal. Paired uteri extend laterally from posterior wall of the genital atrium (Fig. 3) and then turn posteriorly. Hemispherical hard-shelled dormant eggs present in all specimens in posterior part of body; hence uterus has no anterior extensions. Common genital atrium of simple rounded contour, opening ventrally by genital pore distinct from and some distance behind mouth opening (Fig. 4).

Differential diagnosis.—*Mesostoma macroprostatum* differs from all other members of the genus except *M. arctica* Hyman 1938 in the possession of separate seminal vesicle and prostatic vesicle; it differs from *M. arctica* in the greater size of the prostatic vesicle, the large penis papilla at the inner end of a long male canal, and a valve separating the lumen of the penis from the prostatic vesicle.

Locality.—Among vegetation, temporary pond, Medicine Bow Mts., Wyoming, 9700 feet elevation; collected July 2, 4, by Dr. I. H. Blake.

Holotype.—Whole mount; paratype, one set of transverse sections, deposited in the U. S. National Museum; also set of sagittal sections to this institution.

Mesostoma columbianum, sp. nov.

Material.—Two specimens, in collection sent by U. S. National Museum, one perfect, other with posterior end broken away; former made into whole mount, latter sectioned sagittally.

External characters.—Short, plump, with rounded ends (Fig. 5), 1.3 mm. long, stated on label to be very dark gray with white spots (eggs?), whole mount (unstained) appears blue. No eyes detectable on whole specimens, nor can any be found on the sections. Anterior end has on each side a lightly pigmented rounded depressed area, which seems to represent a sensory pit. Sen-

sory pits are not uncommon in the genus *Mesostoma*. The genital pore is separate, some distance behind the mouth, and the posterior three-fifths of the body contains several hard-shelled dormant eggs.

General anatomy.—Histological condition poor; as only one set of sections is available, cut sagittally, some points are difficult to determine. Paired rhabdite tracts present in anterior end leading to either side of the anterior tip, between the pits; they originate from groups of rhabdite-forming gland cells anterior to the brain. Sagittal sections not suitable for study of the sensory pits or areas; unlike the sensory pits of other *Mesostomas* which are devoid of rhabdites, these are provided with closely packed, regularly arranged small rhabdites (Fig. 7). Epithelium of sensory area also shorter than adjacent epithelium and with shorter cilia. Much pigment in ventral parenchyma adjacent to epithelium (Fig. 7) and some pigment granules in the epithelium itself. Pharynx typical, well anterior of the middle. Excretory tubules opening into pharyngeal cavity. Conspicuous brain immediately anterior to pharynx gives off strong branches to the lateral sensory areas (Fig. 5).

Reproductive system.—Testes follicular in median dorsal region as characteristic of the genus; yolk glands scattered throughout the lateral regions. Copulatory apparatus with the general structure typical of the genus but presenting several peculiarities. Apparatus shown in sagittal view in Fig. 6, in which female canal is in front, penis behind, and copulatory bursa between. Female canal does not differ from that usual to the genus. Stalk of copulatory bursa peculiar in having a very thick wall composed of muscle fibers. The stalk ascends from the genital atrium then curves downward so that the thin-walled, somewhat irregular copulatory sac hangs upside down at the level of the oviduct (Fig. 6). The muscular wall of the bursa stalk is composed of a web of fibers running in a general circular direction, mounted on transverse plates of densely staining structureless material. A sphincter of the same structure as the bursa stalk guards the entrance of the stalk into the genital atrium. Penis large and muscular, conforming in general to the construction usual in the genus (Figs. 6, 8). From large cluster of prostate glands at dorsal end of penis, bundle of ducts extends ventrally through middle of penis discharging eosinophilous secretion which fills the lumen of the penis papilla. Wall of penis bulb very thick and muscular, composed of a web of fibers running chiefly in a circular direction, covered externally by a thin coat of longitudinal fibers. Vasa deferentia, coming from anterior direction, pass alongside upper end of penis bulb and enter seminal vesicle, a cavity in the center of the penis bulb, not shown in Fig. 8 as it is behind the bundle of ducts of the prostate glands. Lower end of penis forms a large penis papilla, projecting into the genital atrium; it is lined by a thick, homogeneous layer, presumably a cuticularized epithelium, outside of which is a greatly thickened basement membrane. At its free end, the penis papilla is capped by a valve-like structure the exact nature of which could not be ascertained. Uteri (not shown in any of the figures) extend from posterior wall of atrium as in other Mesostomas and proceed backward.

Differential diagnosis.—*Mesostoma columbianum* differs from other members of the genus in the muscular thick-walled bursa stalk, sphincter at entrance of bursa stalk into the atrium, and large penis with thick muscular wall and central passage for the granule secretion.

Locality.—Pond, Chain Bridge, District of Columbia, April 28th, 1912, collected by R. Shoemaker.

Type.—Whole mount; paratype, one set of sagittal sections; both deposited in U. S. National Museum.

Discussion

These two species together with two others which I have recently described (Hyman, 1938, 1939) constitute a group of Mesostomas of which the copulatory apparatus differs in one or more points from the norm of the genus. Typically in *Mesostoma,* penis, prostatic vesicle, and seminal vesicle are combined into one bulb-shaped organ which receives the prostatic glands and vasa deferentia into its proximal end and bears a small penis papilla at its distal end projecting into the genital atrium. In *Mesostoma arctica* Hyman 1938, there is a separate seminal vesicle and the prostatic vesicle is partially separated from the penis but the penis papilla is small. In *M. macropenis* Hyman 1939 prostatic vesicle and penis are combined into one organ but there is a huge seminal vesicle distinct from this organ and the penis papilla is large. In one of the two present species, *M. macroprostatum,* the seminal vesicle is small but there is an enormous prostatic vesicle distinct from the very large penis papilla. The latter is also at the end of a long canal instead of projecting into the male atrium as usual. In *M. columbianum,* the male apparatus conforms more nearly to that usual for the genus, despite its very large size and muscular construction, but the bursa stalk is peculiar in its extreme muscularity.

It could well be questioned whether one is justified in placing these species in the genus *Mesostoma.* I have spent much thought upon this question, particularly with regard to *M. macroprostatum* but in the end I have been unwilling to create new genera for them. The difficulty is that they do not agree with each other to any extent and it would be almost necessary to erect a new genus for each one. Thus whereas in *M. macropenis,* the seminal vesicle is enormously enlarged, in *M. macroprostatum,* it is the prostatic vesicle which is the prominent feature and in *M. columbianum,* the peculiarities center in the bursa stalk. *M. arctica* and *M. macroprostatum* appear to be the most nearly allied of the four forms. As the general structure of these species, the plan of the sexual complex, the details of the female apparatus, and the relations of the uteri are typical of the genus *Mesostoma,* it has seemed best to retain all four in this genus, at least until more information is available about North American mesostomine rhabdocoels.

The species *M. columbianum* does suggest in some respects the genus *Bothromesostoma* but certainly lacks the two distinguishing features of this

genus, namely, a ventral pit anterior to the pharynx and a duct between the bursa stalk and the female canal.

In my previous statement (Hyman, 1939) that *M. ehrenbergii* was until recently the only *Mesostoma* species known for North America, I had overlooked three earlier papers. Silliman (1884) assigned four species to *Mesostoma* but of these only one, *M. pattersoni*, can possibly belong to this genus. Graff (1913) lists *M. pattersoni* among the doubtful species of Mesostoma. Woodworth (1896) created three new species of *Mesostoma* but only one, *M. wardii*, is valid. Graff (1913) is of the opinion that *M. wardii* is a synonym of *M. ehrenbergii* but this seems to me somewhat doubtful. Two new species of *Mesostoma* were described by Higley (1918) in a taxonomic paper so hopelessly bad that the identity of her forms can never be determined without recovery of specimens from the type localities. It is impossible to decide from her descriptions and figures whether her forms are really *Mesostomas; M. angulare* probably is not, but *M. simplex* might be a member of this genus. It may therefore be said that to 1938, *M. ehrenbergii* was the only definitely established species of *Mesostoma* known to occur in North America.

REFERENCES

Graff, L. von. 1913—Rhabdocoelida. Das Tierreich, Lief. 35.

Higley, Ruth. 1918—Morphology and biology of some Turbellaria from the Mississippi Basin. Ill. Biol. Monographs **4**:195-288.

Hyman, L. H. 1938—North American Rhabdocoela and Alloeocoela. III. Mesostoma arctica, new species, from northern Canada. Novitates Amer. Mus. Nat. Hist. no. **1005**.

———1939—North American Rhabdocoela and Alloeocoela. IV. Mesostoma macropenis, new species, from Douglas Lake, Michigan. Amer. Midl. Natur. **21**:646-650.

Silliman, W. A. 1884—Beobachtungen über die Süsswasserturbellarien Nordamerikas. Zeitschr. wiss. Zool. **41**:48-78.

Woodworth, W. McM. 1896—Report on the Turbellaria collected by the Michigan State Fish Commission during the summers of 1893 and 1894. Bull. Mus. Comp. Zool. Harvard **29**:239-243.

For All Figures

1, pharynx; 2, genital pore; 3, prostatic vesicle; 4, female tract; 5, dormant egg; 6, intestine; 7, yolk glands; 8, brain; 9, pigment; 10, uterus; 11, common genital atrium; 12, prostatic glands; 13, ovary; 14, oviduct; 15, seminal receptacle; 16, valve; 17, penis papilla; 18, male canal; 19, seminal vesicle; 20, rhabdites; 21, muscle layer of penis bulb; 22, eosinophilous secretion in penis lumen; 23, valve-like structure at penis tip; 24, sensory area; 25, copulatory bursa; 26, bursa stalk; 27, sphincter of bursa stalk.

American Museum of Natural History.
New York, N. Y.

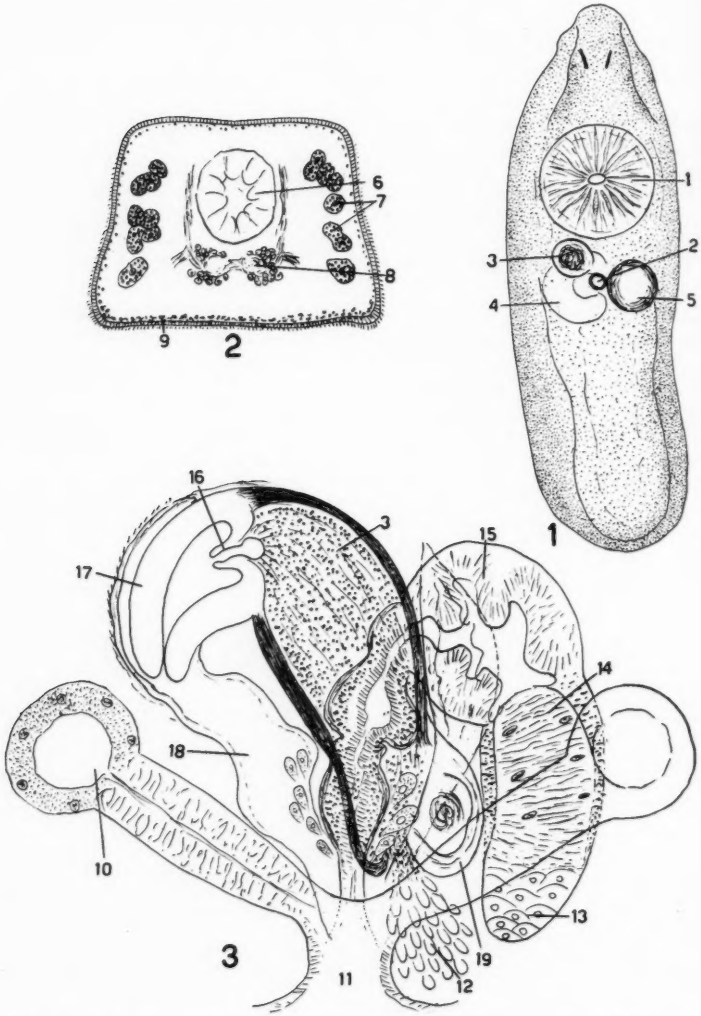

Fig. 1. *Mesostoma macroprostatum*, type specimen. Fig. 2. Cross section of *M. macroprostatum* through the brain region, showing shape of body and distribution of pigment. Fig. 3. Copulatory apparatus of *M. macroprostatum*, constructed from series of transverse sections, seen from behind looking forward; the male apparatus is anterior to the female one; the copulatory bursa is not well shown.

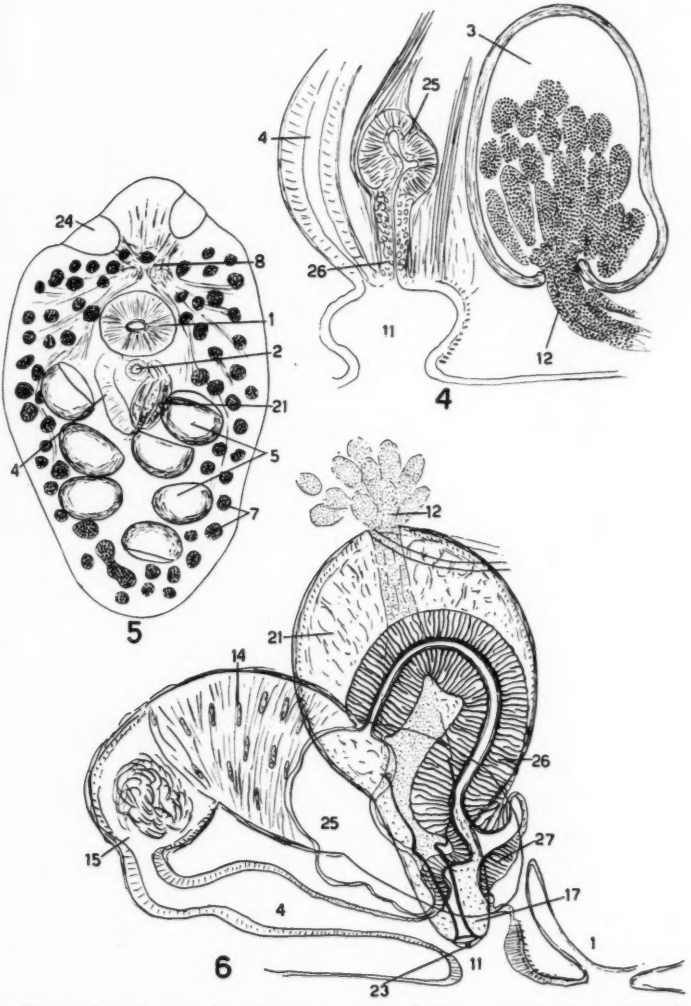

Fig. 4. Sagittal view of copulatory apparatus of *M. macroprostatum*, to show the copulatory bursa and its relation to the female duct; the section also passes through the enormous prostatic vesicle; anterior end to right. Fig. 5. *Mesostoma columbianum*, type specimen. Fig. 6. General view of the copulatory complex of *M. columbianum*, seen from the right side, constructed from sagittal sections; female apparatus in front, male behind, copulatory bursa between; details of the ovary and part of the oviduct have been omitted to show the copulatory bursa, stalk, and sphincter; anterior end to right.

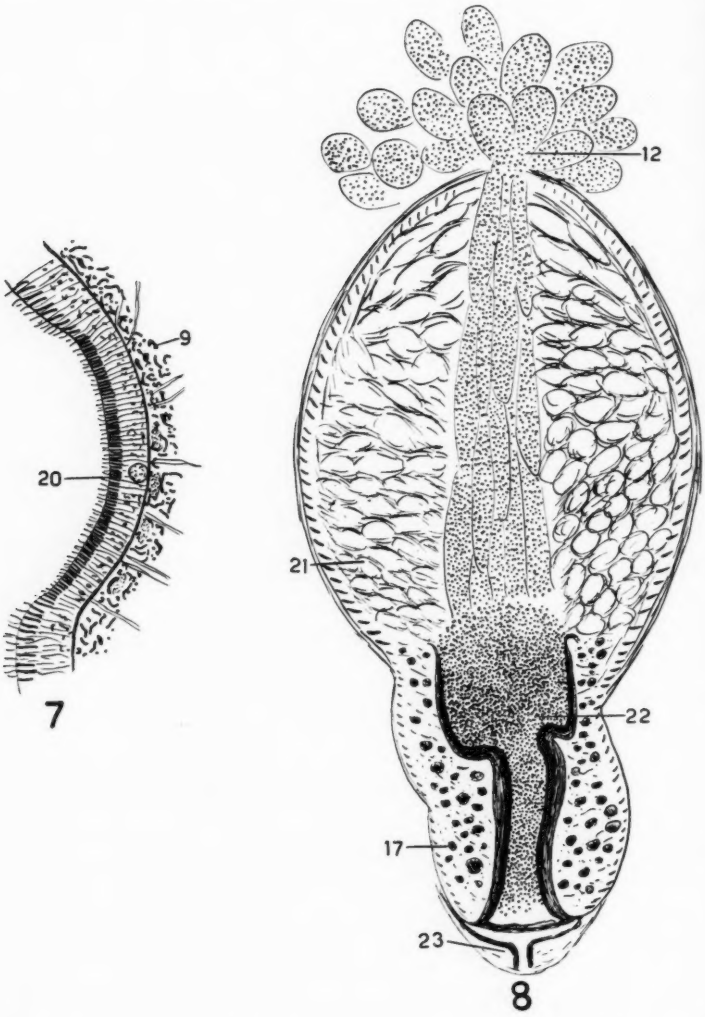

Fig. 7. Sensory area of *M. columbianum*, showing lowered epithelium and regularly arranged rhabdites. Fig. 8. Penis of *M. columbianum* in saggital section.

A New Cestode, Diorchis longibursa, from the Coot*

Gerald M. Steelman

A coot, *Fulica americana americana* Gmelin 1789, taken near Healdton, Oklahoma, in the spring of 1938, was found to harbor two examples of an apparently undescribed cestode for which the name *Diorchis longibursa* is proposed. The worms were fixed in hot 70 percent alcohol and stored until the summer of 1939 when time to study them became available. This description is based upon a study of *in toto* mounts and serial sections of a few proglottids, both stained with borax carmine.

Diorchis longibursa sp. nov.

(Figs. 1 to 5)

General anatomy.—The two strobilae, measured from whole mounts, were 3.3 and 8.65 cm. in length. The longer had 154 immature, 171 mature, and 88 gravid proglottids; the shorter 164 immature, 131 mature, and no gravid segments. Strobila widest in region of gravid proglottids where a maximum width of 1.15 mm. is attained. Segmentation first apparent about 1 mm. behind anterior end of scolex. Segments measure—immature, 0.10 (0.03-0.17) mm. long by 0.29 (0.15-0.48) mm. wide; mature, 0.25 (0.19-0.29) by 0.59 (0.48-0.66) mm.; gravid, 0.32 (0.29-0.37) by 1 (0.88-1.15) mm.

Two pairs of longitudinal excretory canals, the ventral vessels being much the larger and each located slightly aporad to the ipsilateral dorsal one. No transverse canals observed. Inner longitudinal muscles in 8 bundles. Genital pores unilateral and approximately midmarginal. Genital ducts dorsal to porai excretory canals.

Scolex.—Scolex, 0.24 mm. wide, rounded anteriorly. Neck region about 0.88 mm. in length. Suckers large, 0.12 mm. in diameter. Minute spines cover the entire surface of the cavity of the suckers. Rostellum, 0.2 mm. in length and 0.08 mm. in width, retracted in each specimen, possesses 10 hooks which measure 36.7 microns in length.

Male reproductive organs.—Cirrus, extruded in most segments; comprises a long slender distal portion, some 200 microns in length and 7.5 microns in diameter when fully extruded, and a bulbous proximal division about 19 microns in diameter and completely covered with minute spines. Cirrus pouch very long; straight and extending to median line in young mature segments, sinuous and reaching ventrally beyond aporal excretory canals in older ones; maximum length, 0.56 mm.; diameter, 0.04 mm. An internal

* A contribution from the Zoological Labratory, Oklahoma Agricultural and Mechanical College, prepared under the direction of R. Chester Hughes.

seminal vesicle 0.025 mm. in diameter lies inside the pouch and a short vas deferens extends from its aporal end in a posterodorsal direction to open into a large spheroidal external seminal vesicle that measures about 0.13 mm. in diameter. Testes, 2 in number, centrally located one on either side of median line, develop fully before appearance of ovary and degenerate by the time the latter matures.

Female reproductive organs.—Vagina extends mesad from genital atrium to open into a large seminal receptacle near level of poral excretory canals. Receptacle measures 0.14 by 0.07 mm. and extends to about center of proglottid. Ovary, 0.29 mm. in width, composed of three lobes—two lateral and one medial. Vitellarium in median line directly behind ovary, broadly ovoidal, 0.12 mm. in width by 0.04 mm. in length. Oldest proglottids almost completely filled with eggs which are apparently in an immature stage of development. Eggs 18 microns in diameter.

Host.—*Fulica americana americana* Gmelin 1789.

Habitat.—Small intestine of host.

Locality.—Near Healdton, Oklahoma.

Type specimens.—Two strobilae, mounted *in toto*, in the United States National Museum.

Discussion.—The genus *Diorchis* Clerc 1903 contains 18 previously recognized forms. *D. americana* Ransom 1909 and its variety *D. a. turkestanica* Skrjabin 1914, *D. bulbodes* Mayhew 1929, *D. crassicollis* Sugimoto 1934, *D. inflata* (Rudolphi 1819) Fuhrmann 1932, and *D. spinata* Mayhew 1929 differ from *D. longibursa* sp. nov. in having much longer hooks. *D. acuminata* (Clerc 1902) Clerc 1903, *D. jacobii* Fuhrmann 1932, *D. kodonodes* Mayhew 1929, *D. magnicirrosa* Moghe and Inamdar 1934, and *D. nyrocae* Long and Wiggins 1939 all have much shorter hooks than the new species. The great relative length of the cirrus pouch distinguishes the new form from the remaining species—*D. excentrica* Mayhew 1925, *D. microcirrosa* Mayhew 1929, *D. sibrica* von Linstow 1905, and *D. spiralis* Szpotańska 1931. Data on all of the above-named old species of *Diorchis*, compiled by Schultz (1940),** were utilized in comparative studies.

Species of *Diorchis* previously reported from gruiform hosts (species of *Fulica* Linné 1758 in every case) include *D. acuminata, D. americana, D. inflata, D. jacobii,* and *D. longicirrosa.* Forms previously described from North American hosts include *D. americana, D. excentrica, D. bulbodes, D. kodonodes, D. microcirrosa, D. spinata,* and *D. nyrocae.*

** Schultz, R. L. The genus *Diorchis* Clerc 1903. Amer. Midl. Nat. **23**. 1940.

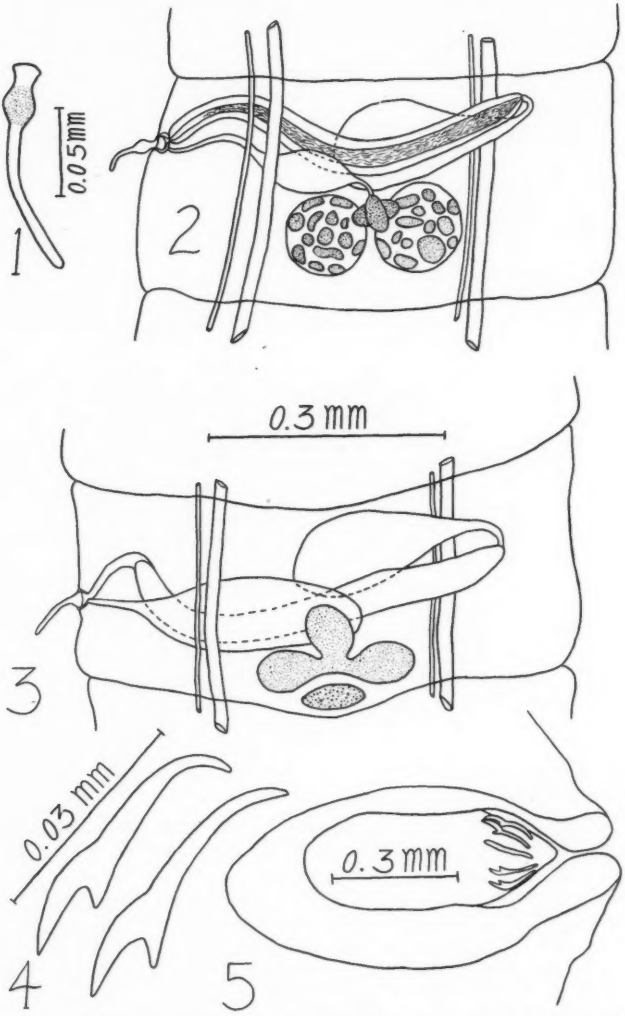

PLATE 1. All figures concern *Diorchis longibursa* sp. nov. and were drawn with the aid of a camera lucida. Figs. 2 and 3 were drawn to the same scale of magnification.

Figs.: 1, Extruded cirrus; 2, Proglottid showing testes at maximum development, ventral view; 3, Proglottid showing mature female organs, ventral view; 4, Two rostellar hooks; 5, Rostellum with apex retracted.

A New Trematode, Acanthatrium oregonense, (Lecithodendriidae), from Bats of the Genus Myotis

Ralph W. Macy

An examination of the intestinal contents of the Northwest Coast bat, *Myotis californicus caurinus* and of the little big-eared bat, *Myotis evotis evotis*, at Nelscott, Oregon, August 13, 1938, yielded 347 specimens of a new species of trematode belonging to the genus *Acanthatrium* Faust, 1919. It is herein described.

Acanthatrium oregonense, sp. nov.

Specific diagnosis.—Acanthatrium: Body pyriform, much flattened dorsoventrally, 0.65 to 0.82 mm. long by 0.65 to 0.83 mm. wide. Cuticula without spines. Oral sucker terminal or nearly so, from 0.078 to 0.087 mm. in diameter. Ventral sucker just anterior to body middle, approximately equal in size to the oral sucker, measuring from 0.085 to 0.09 mm. in diameter. Anterior margin of ventral sucker 0.27 to 0.3 mm. from the anterior end of the body. Pharynx 0.031 to 0.038 mm. long by 0.042 to 0.045 mm. wide. Prepharynx absent. Oesophagus apparently absent. Testes ovate, 0.14 to 0.18 mm. in diameter, located at the terminations of the intestinal cecae. Prostate mass large, average diameter 0.16 to 0.22 mm., bordered anteriorly by cecae, posterior part overlapped by acetabulum. Coiled seminal vesicle opening into genital pore, the latter surrounded by a sphincter muscle and located near the center of the prostate mass. Atrial spines from 0.01 to 0.015 mm. long, directed caudad, arranged in a long crescent between the genital pore and the anterior margin of the prostate mass. Ovary overlapping posterior part of testicular zone, on right side of body axis, 0.07 to 0.11 mm. long by 0.12 to 0.185 mm. wide. Vitellaria in compact masses, reaching from level of pharynx to testes. Eggs average 0.030 mm. long by 0.016 mm. wide. Slings of uterus mainly transverse, largely filling posterior part of body.

Host.—Myotis californicus caurinus Miller; also *Myotis evotis evotis* (A. Allen).

Location.—Intestine.

Distribution.—Nelscott, Oregon.

Type specimen.—U. S. N. M. Helm. Coll., paratypes in same and in author's collection.

Discussion

This species differs from *A. sphaerula* (Looss, 1896) by the single row of longer spines, those of the latter being short and scattered. *A. sphaerula* has the ovary in the anterior zone of the testes and the acetabulum is posterior to the zone of the prostate mass and testes, whereas the ovary of *A. oregonense* is at the posterior level of the testes and the acetabulum overlaps the prostate mass and testicular zone. *A. eptesici*, Alicata, 1932, has atrial spines up to 0.023 mm. long and arranged in a compact mass in contrast to those of *A. oregonense* in which the spines are little more than one-half as long. The sucker ratio of the two species is quite different, the acetabulum of *A. eptisici* being much smaller than the oral sucker, as is also true of *A. nycteridis* Faust,

1919. Also the latter has scattered spines rather than the single row found in *A. oregonense*. The very small spines of *A. molossidis* Martin, 1934, are less than half the length of those of *A. oregonense*.

As to the distribution of the new species in the hosts, 169 were found in 14 individuals of *Myotis evotis evotis*. From one *Myotis evotis* 92 of the flukes were recovered; on the other hand none was found in three *M. californicus*. The average number of *A. oregonense* in *M. californicus* was 12 and the average in *M. evotis* was 44.5. Most of the flukes were mature.

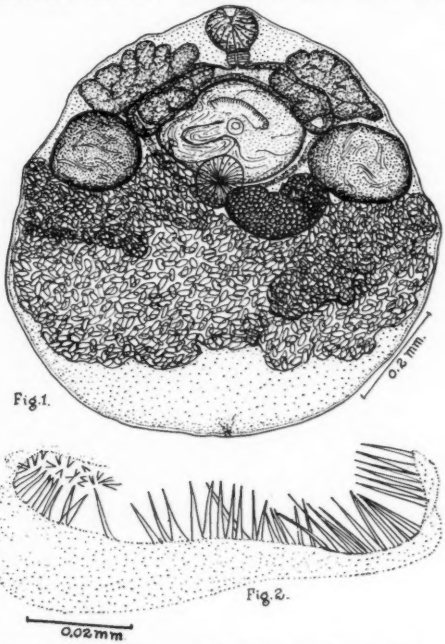

Fig. 1. *Acanthatrium oregonense*, type, dorsal view. Cam. lucida.
Fig. 2. *Acanthatrium oregonense*, atrial spines. Cam. lucida.

REFERENCES

ALICATA, J. E. 1932—A new trematode, *Acanthatrium eptesici*, from the brown bat. Jour. Wash. Acad. Sci. **22**(10):271-274, figs. 1-3.

FAUST, E. C. 1919—A new trematode, *Acanthatrium nycteridis, nov. gen., nov. spec.*, from the little brown bat. Trans. Amer. Micros. Soc. **38**(3):209-215, fig. 1, pl. 20.

LOOSS, A. 1896—Recherches sur le faune parasitaire de l'Egypte. Mém. de l'Institut egypt., le Caire, 3:1-252, pls. 1-16, figs. 1-193.

MARTIN, W. E. 1934—*Acanthatrium molossidis*, n. sp., from the bat *Molossus sinaloae*. Jour. Parasitol. **22**:335.

COLLEGE OF ST. THOMAS,
ST. PAUL, MINNESOTA.

Description of Two New Species of the Genus Eulimnadia and Notes on the Other Phyllopoda of Illinois

N. T. Mattox

The Phyllopod crustacea of Illinois, particularly of the Order Conchostraca, have been given but little attention. The Order Anostraca has been studied and reviewed by Forbes (1876) and Van Cleave (1928). Van Cleave listed three species of Anostracans for the state, *Eubranchipus serratus, E. vernalis,* and *Striptocephalus seali (S. Coloradensis).* The occurrence of *Pristicephalus (Eubranchipus) bundyi* has not been definitely established, so will be omitted in the list and key for the species found in Illinois. Since a complete list, and discussion, has been given for this group the writer will include these forms only as a part of a key for the Phyllopoda of the State of Illinois;—the bulk of the paper will be devoted to a discussion of the Order Conchostraca. The Order Notostraca has not been recorded in Illinois.

Forbes (1876) listed the genus *Lynceus (Limnetis)* as occurring in the state, but gave no specific name or direct reference as to the occurrence of this genus. In published accounts, to the best of my knowledge, the only direct reference to a conchostracan in Illinois is that of the writer's (1937) in his description of *Eulimnadia diversa.* Since that time the writer has been given the privilege of examining the collections of the Illinois Natural History Survey in which a number of other conchostracans were found. The writer at this time wishes to express his appreciation to Dr. D. H. Thompson, of the Illinois Natural History Survey, for making these collections available.

In these collections were found representatives of four species not previously, definitely listed for the State of Illinois. Three genera, *Eulimnadia, Lynceus* and *Cyzicus* were represented. The two species of *Eulimnadia,* upon examination proved to be new species for the genus. Descriptions of these two new species are hereby presented.

Eulimnadia inflecta sp. nov.

The specimens of this species were found by the writer in the collections of the Illinois Natural History Survey. They had been collected August 27, 1924 at Prophetstown, Illinois. There were 10 specimens of this species, 7 females and 3 males, in the Illinois Natural History Survey Collections, which have been considered as co-types. These specimens have characters which are sufficiently different from the other described species of the genus that a new specific name, *Eulimnadia inflecta* is here proposed for this species.

Male: The bivalve shell (Fig. 1) is yellowish, transparent and elongated. The dorsal margin is only very slightly convex; the ventral margin is evenly

rounded. The posterior end of the shell is more truncate than the anterior end. The average length of the shell is 7.3 mm. and the greatest height 4.3 mm. All the male shells had 3 growth lines.

The head (Fig. 6) possesses the typical "frontal organ." The front of the head produces a very characteristic feature for this species: it is strongly concave and much inflected.

The scape of the second antenna (Fig. 6) is short and heavy. Each flagellum has 9 segments. The first antennae is long, extending normally to the middle of the fourth segment of the flagellum, and bears 9 or 10 sensory papillae on its dorsal surface.

The body bears 18 pairs of swimming legs. The first and second pairs are modified into the typical claspers. The first segment of the sixth endite, of the first pair of claspers (Fig. 4) is almost twice as long as the second segment; the second segment is club-like. The sixth endite of the second pair of claspers (Fig. 7) is very long and slender; the second segment is approximately 1.5 times longer than the first segment.

The telson (Fig. 2) is very broad, not so tapering as in other species; two large terminal spines; 16 pairs of spines on the two dorsal ridges; a forked filament arises beteewn the sixth and seventh pairs.

Female: The female shell (Fig. 3) is similar to, but larger than that of the male. The dorsal margin is very much more convex; the greatest height is near the middle; the ventral margin is broadly rounded. The average length of the shell is 8.1 mm. and the greatest height 6 mm. The lines of growth vary in number from 3 to 4; 4 is the usual number.

The head (Fig. 5) is simalar to that of the male, it is also strongly inflected.

The flagella of the second antennae, as in the male, have 9 segments. The first antennae are shorter, extending out to the end of the first segment of the flagellum; this is longer than in most species.

The swimming legs, 18 pairs, are all of the same general, swimming, phyllopod type.

The telson is similar to that of the male. The number of pairs of dorsal spines vary from 13 to 19, with 16 the average number.

The eggs (Fig. 8) are rounded with an irregularly ridged surface. They are 0.2 mm. in diameter.

This species, *E. inflecta*, exhibits the sexual dimorphism in the length of the first antennae as found in *E. diversa*. The shell of the male is more broadly oval on the dorsal margin than the other North American species. With the exception of *E. diversa*, which is smaller and has only 2 lines of growth, there are fewer growth lines than in the other species.

The first antenna of the male is longer in proportion than any of the other species. The first segment of the sixth endite of both of the male claspers is much longer in proportion to the second segment than in other species. The

average number of dorsal spines on the telson, 16, is greater than that of the other North American species except *E. texana,* which also has 16.

Eulimnadia thompsoni sp. nov.

Specimens of this species were also discovered by the writer while examining the collections of the Illinois Natural History Survey. They had been collected August 7, 1901 in pools in the rocks on an island in the Illinois River above Ottawa, Illinois. There were 12 specimens, 10 females and 2 males, and are catalogued in the Illinois Natural History Survey collections under Cat. No. 28235. These 12 specimens have been considered as co-types. These animals were so different from other members of this genus that a new specific name of *Eulimnadia thompsoni* is here proposed for this species. The writer, in this name, is hereby honoring Dr. D. H. Thompson of the Illinois Natural History Survey for the privilege of examining its collections.

Male: The bivalve shell (Fig. 9) is yellowish transparent and elongately oval. The dorsal margin is very convex, especially near the middle of the shell; the ventral margin is rounded. The posterior end of shell is broadly truncate, anterior end rounded. The greatest height of the shell is near the middle of the shell. The average shell length is 8.1 mm.; and the greatest height of the shell is 5.5 mm. Both male shells examined had 5 growth lines.

The head (Fig. 14) possesses the typical "frontal organ." The front of the head is slightly concave with the ventral portion rather truncate.

The scape of the second antenna is very long. Each flagellum has 9 segments. The first antenna is very long, extending ventrally to the third segment of the flagellum, and bears 10 or 11 sensory papillae on its dorsal surface.

The body bears 18 pairs of swimming legs. The first and second pairs are modified into the typical claspers. Basal segment of first pair broad, not deeply notched as in other species. The first segment of the sixth endite, of the first pair, (Fig. 12) is longer than the narrowed second segment. The sixth endite of the second pair of claspers (Fig. 16) is very long and narrow; the second segment approximately 1.4 times longer than the first segment.

Telson (Fig. 10) is broad, tapering down to two large, elongated terminal spines; 15 pairs of spines on the two dorsal ridges, a forked filament arises between the third and fourth pairs.

Female: The female shell (Fig. 11) is similar to, but larger than that of the male. The dorsal margin is more convex, the greatest height is anterior to the middle. The ventral margin is more broadly rounded. The average length of the shell, taken from ten specimens, is 9.6 mm. and the greatest height 5.9 mm. The lines of growth vary in number from 6 to 11; 7 is the average number.

The head (Fig. 13) is similar to that of the male.

The flagella of the second antennae, as in the male, have 9 segments. The first antennae are small, extending out to near the middle of the scape.

The swimming legs, 18 pairs, are all of the same general, swimming, phyllopod type.

The telson is similar to that of the male. The number of pairs of dorsal spines varies from 14 to 20, with 17 the average number.

The eggs (Fig. 15) are rounded, with an irregular ridged surface. They are 0.4 mm. in diameter.

This species, *E. thompsoni,* exhibits the same sexual dimorphism in the length of the first antennae as found in *E. diversa* and *E. inflecta.* The shell of the male is more markedly convex on the dorsal margin than the other North American forms. It is larger than other Nor. Am. forms with the exception of *E. stoningtonensis,* which is 8.5 by 6.0 mm. With the exception of *E. stoningtonensis,* which has 10 lines of growth, and *E. texana,* which has 5 lines of growth, there are more growth lines than on other species. The first antennae of the male extend to the third joint of the flagellum of the second antennae, which is longer than the other species with the exception of that of *E. diversa* which extend to the fourth segment, and *E. inflecta,* which extend to the middle of the fourth segment. First segment of the sixth endite of the first clasper is slightly longer than the second segment; the second segment of the sixth endite of the second clasper is 1.4 times longer than first segment. In the other species the segments are nearly the same length, except *E. inflecta,* which is 1.5 longer. The egg of this species is larger than that of any of the other species, being 0.4 mm. in diameter, while the others are only 0.2 mm. in diameter.

Eulimnadia diversa (Figs. 17-25) as described by the writer (1937), is one of the species for this genus found in the State of Illinois. Collections of *E. diversa* have been made by the writer at Urbana in 1933, '34, '35, '36, and '37. At each appearance these animals were present in large numbers and always in temporary, shallow pools. The normal appearance for these forms apparently is in the late spring, generally during the month of May. However, the writer made one collection of this species in October, 1936. The animals observed at this time did not reach maturity in the pond, but did develop normally when brought into the laboratory. Notes on the development and life history are presented by the writer in the above mentioned paper. This species has been taken only at Urbana.

Lynceus brachyurus brachyurus (Limnetis gouldi) (Figs. 32-38) is probably the species referred to by Forbes (1876) as the *(Limnetis,)* occurring within the State of Illinois. However, no definite specific name nor locality was mentioned by Forbes. This small, rounded conchostracan was collected by the writer at Urbana in May, 1936. They appeared in a temporary woodland pool which had contained *Eubranchipus serratus* earlier in the season, the *Eubranchipus* having disappeared about a month before the appearance of the *Lynceus.* It was noted that these animals reached maturity, females were carrying eggs, approximately 20 days after their appearance and lived about 6 days after reaching maturity.

In the collections of the Illinois Natural History Survey were found specimens of *L. brachyurus*[1] that had been taken near Normal, Illinois and also some taken near Rock Island, Ill. These collections indicate that the species is probably found throughout the state and is probably more widespread than these collections indicate. The species has been recorded from numerous localities in eastern and central America, westward to the Mississippi River.

Cyzicus mexicanus (Estheria mexicanus) (Figs. 26-31) has not previously been recorded from the State of Illinois so far as the writer is able to determine. In the collections of the Illinois Natural History Survey there are several collections of this species taken from Havana, Quincy, and East St. Louis, Illinois. This large conchostracan, the largest species in the Illinois group, is readily separated from the other species on the basis of the clam-like shell with 20 or more growth lines. It appears during the late spring and summer, from May to August, frequently occurring in large numbers.

The occurrence of this species in Illinois is not surprising as it has been taken in Ohio, Kentucky, Kansas, Nebraska, Manitoba, New Mexico, and Mexico. This would indicate a very wide distribution and the probability of occurrence in many localities not yet recorded.

Key to the Illinois Phyllopoda

A. No carapace; eyes stalked; head of male with second antennae modified into claspers. ..... Order *Anostraca* Sars

B. Head of male bearing a frontal appendage on the base of each biarticulate, clasping antenna. ..... Genus *Eubranchipus* Verrill

C. Frontal appendage extending beyond basal segment of clasping antenna; frontal appendage deeply serrated; terminal segment of clasping antenna with a process pointing inward half as long as the segment. ..... *Eubranchipus serratus* Forbes

CC. Frontal appendage short never extending beyond basal segment of clasping antenna; frontal appendage with small teeth; long terminal segment of clasping antenna with a process pointing inward one fourth the length of the segment. ..... *Eubranchipus vernalis* (Verrill)

BB. No frontal appendage; clasping antenna triarticulate. Terminal branches appearing like the blades of scissors. ..... Genus *Streptocephalus* Baird

D. Cercopods of male bowed, with short spines on distal half and long bristles on proximal half. ..... *Streptocephalus seali* Ryder

AA. Body completely enclosed in a bivalve carapace; eyes not stalked; second antennae biramose. ..... Order *Conchostraca* Sars.

B. Shell without lines of growth, nearly sperical; first pair of legs of male prehensile. ..... Genus *Lynceus* Muller

C. Head beak-shaped, broad in male and acuminate in the female; length of shell from 3 to 4 mm. ..... *Lynceus brachyurus brachyurus* Muller

BB. Shell with lines of growth; first and second pair of legs of male prehensile.

D. Head with frontal process; spine on lower surface of telson; 2 to 10 lines of growth on carapace. ..... Genus *Eulimnadia* Packard

E. Male shell length 4.2 mm.; breadth 2.5 mm.; 2 lines of growth; 12 pairs of dorsal spines on telson, a forked filament arising

between third and fourth pair; egg 0.2 mm. in diameter. .....
.....*Eulimnadia diversa* Mattox

EE. Male shell length 7.3 mm.; breadth 4.3 mm.; 3 lines of growth; 16 pairs of dorsal spines on telson and a forked filament between the sixth and seventh pair; egg 0.2 mm. in diameter. .....
.....*Eulimnadia inflecta* Mattox

EEE. Male shell length 8.1 mm.; breadth 5.5 mm.; 5 lines of growth; 15 pairs of dorsal spines on the telson and a forked filament between the third and fourth pair; egg 0.4 mm. in diameter.
.....*Eulimnadia thompsoni* Mattox

DD. Head without a frontal process; carapace with many lines of growth; flagellum of second antenna with 16 or 17 segments; rostrum of male spatulate, female acute. .....Genus *Cyzicus* Adouin

F. Length of shell 10 to 15 mm.; telson with 30 to 50 teeth above; shell rounded above with prominent umbones near anterior end; 24 lines of growth. .....*Cyzicus mexicanus* (Claus)

REFERENCES

BERRY, E. W. 1926—Description and notes on the life history of a new species of Eulimnadia. Am. Jour. of Sci. Fifth Series. **11**:429-433.

FORBES, S. A. 1876—List of Illinois crustacea with descriptions of new species. Bull. Ill. Museum of Natural Hist. **1**:3-25.

MATTOX, N. T. 1937—Studies on the life history of a new species of fairy shrimp, Eulimnadia diversa. Trans. Am. Micro. Soc. **56**(2):249-255.

PACKARD, A. S. 1883—A monograph on the phylopod crustacea of North America. Twelfth Ann. Rep. U. S. Geol. Sur. Terr., Hayden, 1.

VAN CLEAVE, H. J. 1928—The fairy shrimps of Illinois. Trans. Ill. Acad. Sci. for 1927, **20**:130-132.

EXPLANATION OF PLATES

SYMBOLS USED: 'ant'—antenna (first, second); 'en'—endite (fourth, fifth, and sixth); 'fb'—flabellum; 'fp'—frontal process; 'g'—gill; 'l'—Labrum; 'm'—mandible. Scale indicated equals 1 mm.

MIAMI UNIVERSITY,
OXFORD, OHIO.

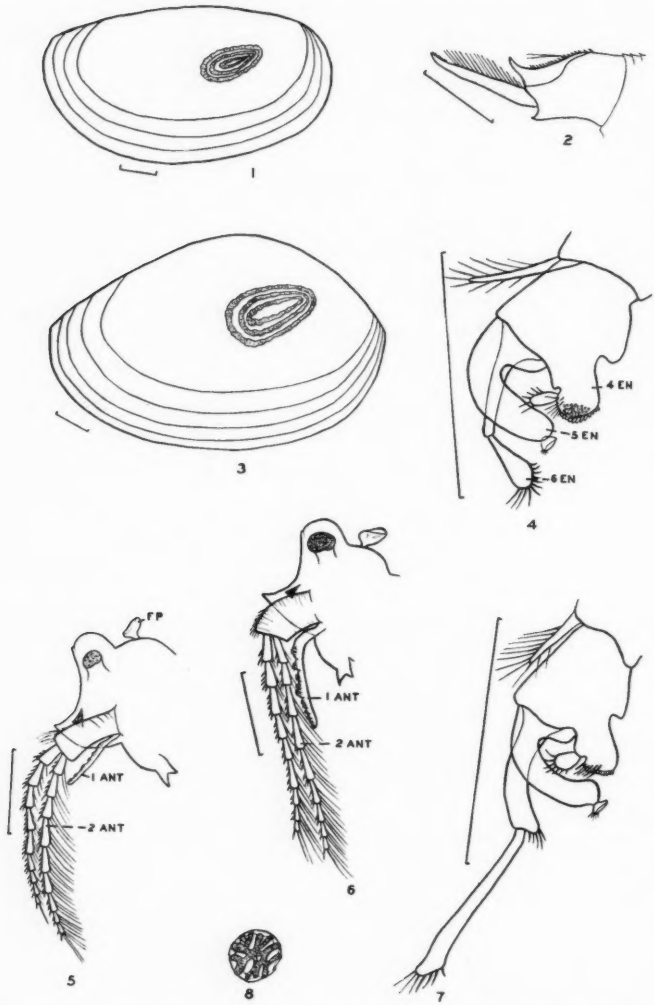

PLATE 1. *Eulimnadia inflecta* n. sp. Fig. 1, Lateral view of male shell; 2, Lateral view of telson; 3, Lateral aspect of female shell; 4, Lateral view of first male clasper; 5, Lateral aspect of female head; 6, Lateral aspect of male head; 7, Lateral view of second male clasper; 8, Egg.

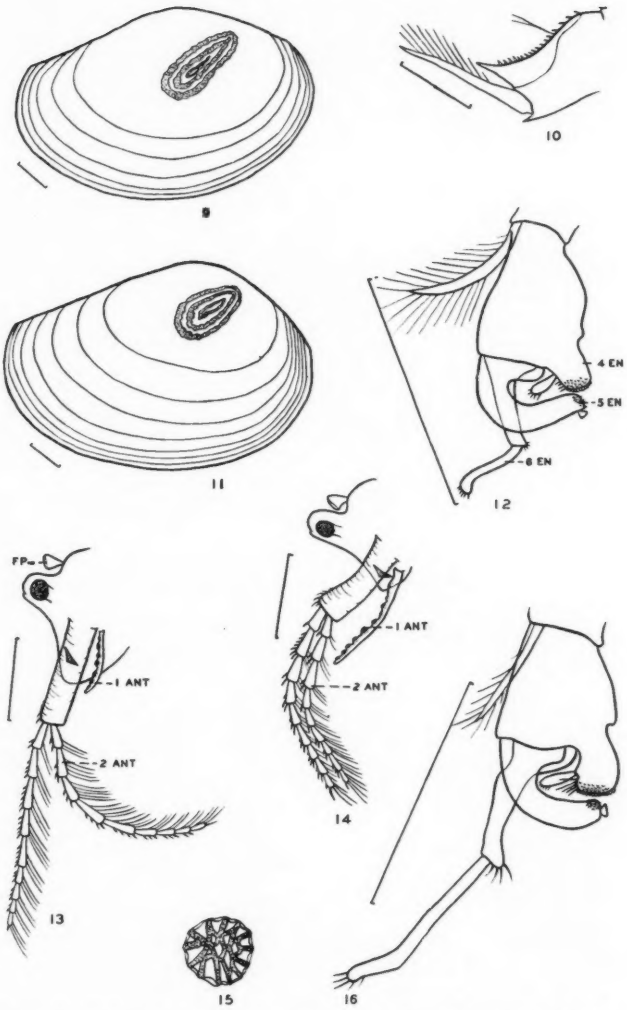

PLATE 2. *Eulimnadia thompsoni* n. sp.: Fig. 9, Lateral view of male shell; 10, Lateral aspect of the telson; 11, Lateral view of the female shell; 12, Lateral aspect of the first male clasper; 13, Lateral view of the female head; 14, Lateral view of the male head; 15, Egg; 16, Lateral aspect of the second male clasper.

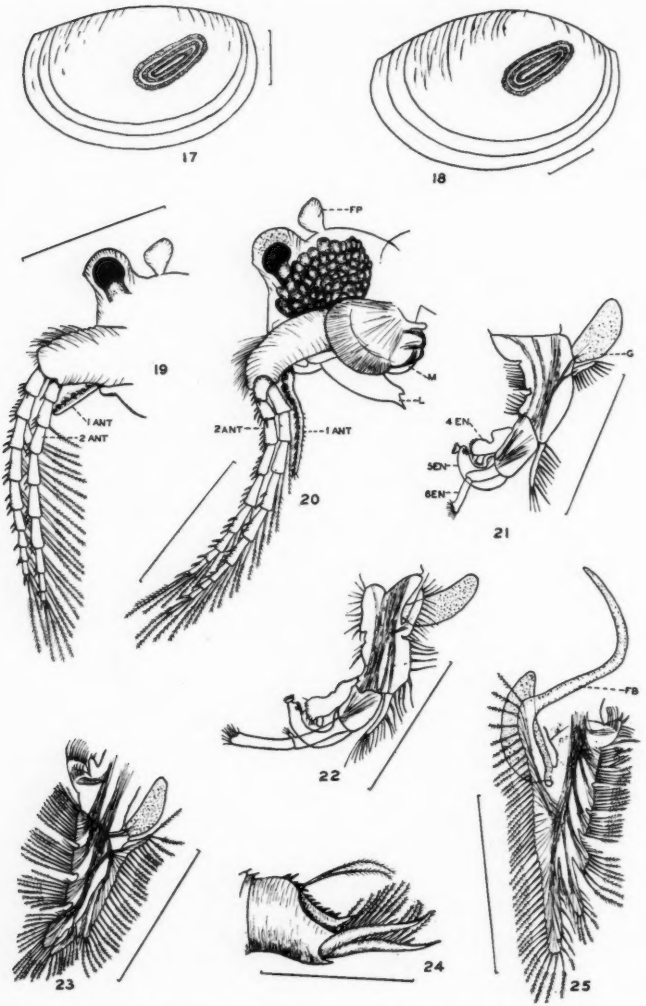

PLATE 3. *Eulimnadia diversa:* Fig. 17, Lateral view of the male shell; 18, Lateral view of the female shell; 19, Lateral aspect of the female head; 20, Lateral aspect of the male head; 21, Lateral view of the first male leg; 22, Lateral view of the second male leg; 23, Lateral view of the first female appendage; 24, Lateral view of the telson; 25, Lateral view of the tenth female appendage.

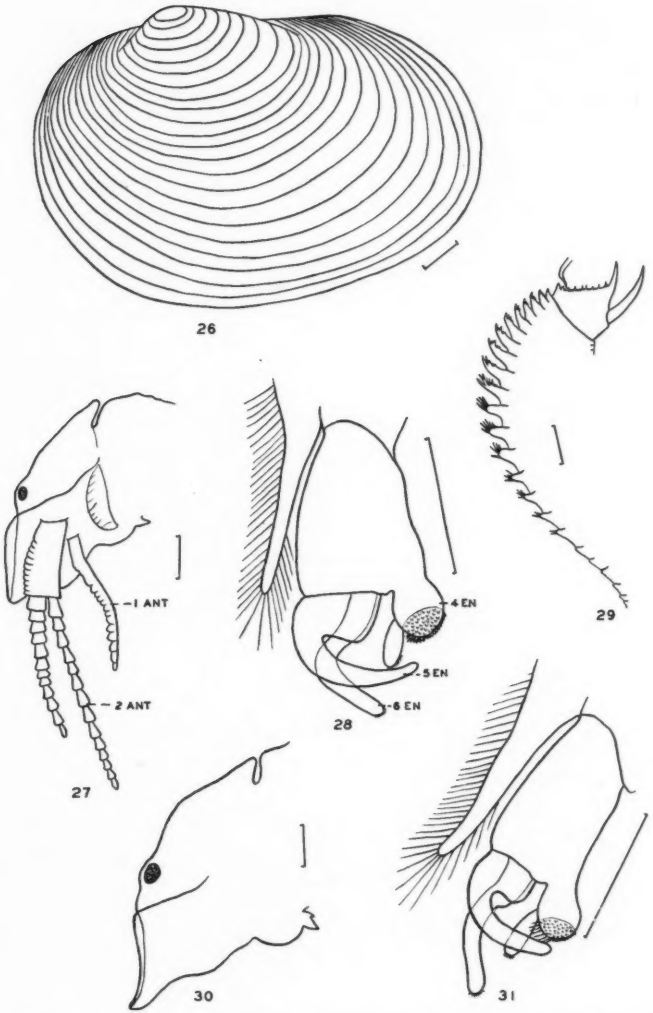

PLATE 4. *Cyzicus mexicanus:* Fig. 26, Lateral view of the shell; 27, Lateral aspect of male head; 28, Lateral view of the first male clasper; 29, Lateral aspect of the telson and dorsal portion of the adbomen; 30, Lateral aspect of the female head; 31, Lateral view of the second male clasper.

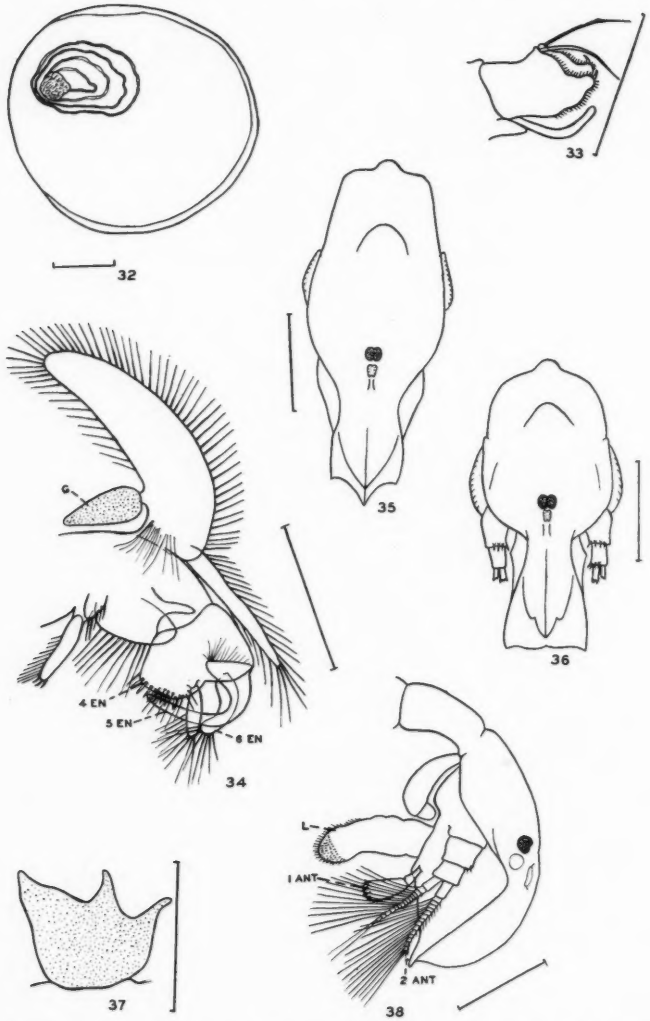

PLATE 5. *Lynceus brachyurus brachyurus:* Fig. 32, Lateral view of the shell; 33, Lateral aspect of the telson; 34, Lateral view of the first male appendage; 35, Frontal aspect of the female head; 36, Frontal aspect of the male head; 37, Lateral view of the abdominal lamina; 38, Lateral aspect of the male head.

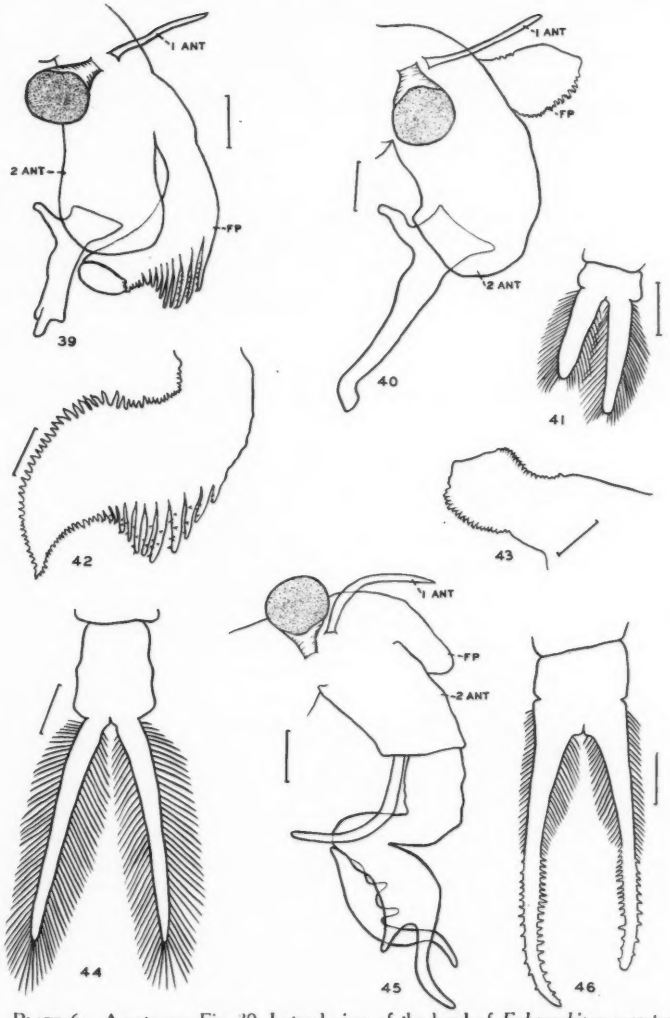

PLATE 6. Anostraca: Fig. 39, Lateral view of the head of *Eubranchipus serratus;* 40, Lateral view of the head of *Eubranchipus vernalis;* 41, Dorsal aspect of the cercopods of *Eubranchipus vernalis;* 42, Dorsal aspect of the frontal process of *Eubranchipus serratus;* 43, Dorsal aspect of the frontal process of *Eubranchipus vernalis;* 44, Dorsal aspect of the cercopods of *Eubranchipus serratus;* 45, Lateral aspect of the head of *Streptocephalus seali;* 46, Dorsal aspect of the cercopods of *Streptocephalus seali.*

Notes on Marine Aquarium Animals

Herbert William Jackson

Published observations on the natural history of marine animals such as those of MacGinitie (1937, 1938) have suggested that notes on the aquarium behavior of other forms may be of interest. The observation of animals under natural conditions is admittedly of paramount importance, but their observations under experimental or abnormal conditions likewise should not be neglected.

There is comparatively little mention of what might be termed "aquarium natural history" in the literature. Too often phenomena observed in aquaria are written up as the normal behavior of an organism in nature without mention of the conditions under which the observation was made. Needless to say, a tremendous amount of information can be gleaned from animals in aquaria, but it must be interpreted with the aquarium in mind, and checked with observations in the field. Thus the laboratory naturalist and the field naturalist should work together, preferably in the same person, but failing that, through the literature.

Mention has often been made of the fact that marine aquaria for inland laboratories are neither impossible nor difficult to achieve and I would like to reemphasize that statement at this point (Galtsoff 1937, Thomas, 1927). The aquaria on which most of the following notes were made are located at Cornell University at Ithaca, New York, some four hundred miles from the writer's collecting ground, and have been maintained in a very simple fashion for the past eighteen months (They were set up January 3, 1938). Elaborate equipment has been purposely avoided in order to study the opportunities open to those with meager facilities. Specifically, this equipment consists of three aquaria; two rectangular glass aquarium tanks 24 inches long by 12 inches wide by 11 inches in height, and one 12 inches long by 8 inches wide by 8 inches high. One of the large tanks has been balanced since June of 1938, the other has been areated most of the time and has been used for experiments, the reception of new specimens, etc. The small tank has been useful for demonstration in the laboratory and at lectures, and exhibitions. The original water is still in use and has never been filtered, stored, or otherwise treated except by the addition of distilled water to compensate for evaporation. Thus, though filtration or adjustment of pH may be desirable, it is not essential.

Field observations and collections were made at the Isles of Shoals Marine Zoological Laboratory of the University of New Hampshire, located off Portsmouth, New Hampshire.

Coelenterates

Movement.—It has often been noted that the sea anemone is capable of a "limited amount" of movement on its basal disc, but the literature is scanty as to definite figures or measurements on the amount, rate or method of movement.

A specimen of *Metridium marginatum* (Lesson) newly placed in the aquarium soon attached itself to the front glass. It moved but little for two days, and then on the morning of the third day was found to have moved to a rock some two inches away from the glass. In order to reach this rock it had to cross a patch of Periwinkle (*Littorina litorea* Linnaeus) and other shells with which the bottom was covered, showing that this species will, on occasion, voluntarily leave a firm substrate for loose gravel or shells temporarily.

The specimen moved about over the stone for two or three days, then back to the front glass of the tank and for the next month continued to follow a tortuous path around the tank.

Movement seems to be accomplished by a series of purely muscular movements. The basal portion first becomes lobulated and distended with water. A lobe will be slowly pushed out and in from two to five minutes it can be seen that it is becoming flattened against the glass of the aquarium. Other lobes will slowly push out and merge with the first one, and in half an hour the margin of the basal disc can be seen to have moved a quarter of an inch or more. Lobes on the opposite side of the disc appear to be released in the reverse fashion. The central portion of the disc slides along, a small area at a time, something like the Periwinkle which "walks" along the glass by sliding first one side of its foot forward and then the other.

The above specimen was observed on March 23rd to move four inches in one hour, the base being extremely distended with water. At the end of that time, its hold was so loosened that it tipped downward, hanging to the glass by but a single lobe, and ten minutes later fell to the bottom of the tank..

Budding.—Budding has often been observed in *Metridium m.*. The basal disc spreads widely over the substrate and small terminal pieces become detached in the course of several days. No tentacles have been observed until after separation from the parent. Young individuals soon acquire four or five tentacles and new ones appear around the outer side of the hypostome.

One specimen was observed to remain spread in the above condition from the first to the twenty-second of March, when it moved three inches to the other side of the rock, leaving behind four small brown discs of tissue, ranging from three to five millimeters in diameter. By May 1st these had grown until the largest one had a body length of nearly ten millimeters when extended, and a diameter of about two millimeters, with twenty-eight tentacles in its hypostome. The smallest was five millimeters in height by one and one-half millimeters in diameter and had only twelve tentacles.

Longitudinal fission was observed but once, in 1930, at the Isles of Shoals.

Acontia Threads.—Acontia threads of *Metridium marginatum* (Lesson) have been observed to be retracted through the cinclides in from 10 to 30 minutes, depending on the length extruded. Those thrown out through the mouth were retrac ed in about the same length of time. The writer has never observed an acontia thread to be discarded that was not broken off by some outside force, even when they have been extruded in such abundance as to form a writhing white mass of threads over the entire surface of the animal.

The stinging effect of the acontia threads was observed on *Littorina litorea* Linnaeus, the common Periwinkle when an acontia thread fell across the foot on one by chance. The portion of the foot for an eighth of an inch on either side of the spot touched immediately contracted strongly as if under intense stimulation, and the snail made every effort to crawl away as rapidly as possible (if a snail ever "hurried," this one did!)

Echinoderms

Disease.—A peculiar corrosion, possibly a fungus growth, of the tips of the arms of *Asterias vulgaris* Verrill and *Asterias forbesi* (Desor) has been observed frequently in specimens recently brought from the ocean. This usually spreads toward the disc until the arms are cast off one by one. The animal usually dies after losing three or four arms.

The infection appears as a greyish blotch two or three millimeters across, near the tips of the arms, and spreads until it covers about two-thirds of the dorsal surface of the arm in an irregular fashion, when the member is cast off. That the affection is largely confined to the dorsal surface is shown by the fact that the tube feet of an arm recently cast off will remain active and distended throughout its length for from two to twelve hours afterward.

Occasional specimens recover by casting off affected arms before the infection reaches the disc. Regeneration has been observed to begin within one to two weeks after the loss of as many as three arms.

What seems to be the same affection has been noted as an irregular whitish patch of diseased tissue on the middle portion of a sea cucumber, *Thyone briareus* (Lesueur). The individual in question is still alive at this writing and the affected area has decreased from about 14 x 9 mm. to 10 x 7 mm., in the last three months.

This specimen eviscerated soon after arrival on February 16th and has successfully recovered under aquarium conditions.

Hermit crabs *Pagurus longicarpus* Say have been observed picking off the tube feet of *Thyone* and eating them. This is either an indication of what may happen when a *Thyone* is exposed by currents or other accident, or the abnormal selection of the crabs in the artificial environment.

Arbacia punctulata (Lamarck)

Movement.—Arbacia punctulata (Lamarck) has been observed to move over the glass of an aquarium at the rate of 35-40 mm. per minute after having been disturbed. The average of 25 minutes measured at five different times when undisturbed and not feeding was 22.2 mm. per minute. This included two minutes with 37 mm. and 40 mm. respectively. After having been repulsed by the acontia threads of a *metridium* on which it was attempting to feed, one specimen was observed to move 60 mm. straight downward in 40 seconds, and 15 mm. more in the next 20 seconds, when it stopped and did not move again for 35 minutes.

Regeneration.—All of the spines were removed from one radius of two different specimens of *Arbacia* on June 6. On July 6, all spines had regenerated to slightly more than half of their normal length. The circumoral flat spines with an average normal length of 5 mm., had regenerated to a length of 3-4 mm. The long spines normally 10-12 mm. in length had regenerated to a length of 5-6 mm. The short circumanal spines, ranging normally from 2-4 mm., had regenerated to a length of from 1-3 mm.

Young regenerating spines have the normal sized base, that is, about 1.5 mm. in diameter. They taper sharply from this point for about 1-2 mm., and then lengthen out into a rather sharp tip.

Feces.—Arbacia p. has been observed to drop small white oval pellets, 1 mm. x 2 mm. These dissolve readily in HCL and appear to consist largely of calcium ejested after feeding on calcareous encrusting algae of the *Corallinaceae.* After the urchins have been feeding on these algae from rocks in the bottom of the aquarium, these pellets are common in the hollows of empty Mytilus shells and other such places. When they are feeding on the green slime on the walls of the aquarium, the pellets are greenish in color.

Mollusca

Mytilus Feces.—The castings of *Mytilus edulis* Linnaeus, are often found in abundance in quiet pools at low tide where these animals are present. They are in the form of thin, gray ribbons, 2 mm. wide, less than ½ mm. in thickness, and often ten to twenty or more centimeters in length. They may often be observed sliding from between the valves in quiet water and drifting in loose folds over the surrounding pool bottom. This may also be observed in the aquarium.

Aquarium Food

A clam or oyster from the local market when dried on a radiator at 80°-90° C. makes excellent aquarium food for such animals as crab and sea anemones. Among the advantages of this food are that it is easily obtained and prepared, keeps well in an air tight bottle, and small pieces dropped by the animals will not so quickly foul the tank as fresh food. Small pieces 5 to 10 mm. across may be broken off and fed directly to the animals in the tank, thus

eliminating the troublesome task of removing them to separate feeding containers.

Transportation and Storage of Marine Animals

The collector is occasionally faced with the problem of transporting marine animals without facilities for carrying them in sufficient water. The writer has found various modifications of the following method of "dry packing" useful under such conditions. This method consists essentially of using an abundance of moist seaweed such as *Ascophyllum* Stackh., or *Fucus* L. for packing and insulation, and protecting the animals from being crushed or dried. No water at all is poured into the container as long as there is enough moisture to keep surfaces from drying.

Most littoral animals live far better under these conditions than when the container is filled with water, which tends to become warm and foul. As long as external respiratory organs are covered with water, metabolism proceeds at the usual pace until the O_2 is rapidly exhausted and the CO_2 approaches toxic concentrations. If no water is present, however, as is of course the case for many of these animals at every low tide, external respiratory organs are exposed to the air and respiration is very much reduced. It is known that in certain molluscs under these conditions, the CO_2 concentration rapidly builds up within the body to a point where general metabolism is virtually stopped, and apparently the same thing happens in other invertebrates.

A collection for a small aquarium, making ample allowance for selection and mortality, may be packed in a series of strawberry boxes slipped inside one another. These boxes should first be well soaked in sea water, then separated and the specimens distributed between them, being carful to avoid overcrowding. Since the inside clearance between the bottoms, when they are stacked, amounts only to the width of the rim, or about ½ inch, only the smaller forms should be placed in the lower boxes. Large forms such as sea urchins or large sea anemonae may be placed in the open top box.

The boxes should be stacked and set on an inch or so of rockweed in the bottom of a large pail or preferably a wooden bucket. They should then be surrounded and covered with more rockweed and the whole covered with a piece of burlap, which, if kept moist, will aid materially in reducing the temperature in warm weather.

It has been found that animals packed in the above manner will survive for two to four days in the warmer seasons if kept in the shade, or a week or longer in cold weather. A considerable quantity of *Ulva l.* or other green algae, such as *Enteromorpha* Link, may well be included in the packing for use as an oxygen supply later on, to say nothing of decoration. Irish moss (*Chondrus crispus* (L.) Stackh.) too lives well in aquaria, is colorful, and also makes good packing.

Using methods similar to the above, the writer has been able, for example, to make a collection on the New England coast in December and to successfully establish an aquarium 400 miles inland (Cornell University, Ithaca, New York), six days later. Water was carried in two 5 gallon carbuoys.

Transportation of Aquaria

Established aquaria may be most readily moved from room to room or from building to building by siphoning off the water into a glass carbuoy or other non-metal container. All of the animals with the possible exception of fishes may be left undisturbed and the tank simply carried with a minimum amount of rough treatment to its destination. The water should be siphoned back from the carrying container into the aquarium, and not poured, at least until the tank is half full or more, to avoid stirring up the bottom. Sediment stirred up will soon settle out and the water will return to its former clarity.

REFERENCES

Galtsoff, S. 1937—Marine Aquaria in "Culture Methods for Invertebrate Animals." Comstock Publishing Co., Ithaca, N. Y.

MacGinitie, G. E. 1937—Notes on the Natural History of Several Marine Crustacea. Am. Mid. Nat. **18**(6):1031-1037.

———1938—Notes on the Natural History of Some Marine Animals. Am. Mid. Nat. **19**(1):207-219.

Thomas, L. J. 1927—Marine Aquaria for High Schools and Colleges. Trans. Illinois State Acad. Sci. **20**:125-128.

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The Geographic Distribution of Acrididae in Northern Oklahoma*

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Introduction

The Acrididae have a wide distribution, characterizing in particular the grassland regions of the world. The number of species is approximately 11,000. Their distribution is confined in general to the temperate and torrid zones and they are found in every continent. In the Great Plains region of North America, which includes western Oklahoma, approximately 225 species have been determined. Although rather extensive studies have been made in the states of the Great Plains region north of Oklahoma, the factors which affect distribution have not been emphasized. For these reasons the Acrididae are afvorable material for a study of distribution as correlated with climatic, vegetational, and topographic factors.

A study of broad application would necessarily be made up of a number of local studies. Ideally, collections should be made over the entire North American grasslands in such a way that comparisons could be drawn between the Acridian components of each of the subdivisions of this formation. Since conditions are now unfavorable for extensive studies of this nature, this is only a minor contribution toward such a goal, but differing in that the area under investigation embraces several ecologically different communities and that extensive collections from uniform areas are not available. Additional studies are necessary for a complete understanding of the distribution of the Acrididae.

T. H. Hubbell and A. I. Ortenburger (1926) listed all the species of Orthoptera definitely recorded from Oklahoma. Scudder's "Index to North American Orthoptera" (1900) contains records of seven species from Oklahoma and Indian Territory. Caudell (1902) published "Notes on Orthoptera from Oklahoma and Indian Territory," including descriptions of three new species. Records of Acrididae from central and southeastern Oklahoma are found in Morse (1907).

Ninety-one species of Acrididae were reported by Hubbell and Ortenburger. The writer has identified ninety-two species in northern Oklahoma, eight of these new to the state. From the present study, it is evident that northwestern Oklahoma has the greatest abundance of species, particularly Harper, Ellis, and Woodward counties.

The material on which this paper is based consists of a collection of approximately 7,000 specimens from the Department of Entomology of the Oklahoma Agricultural and Mechanical College at Stillwater, Oklahoma, and a few collections made by the writer in Payne, Pawnee and Noble counties. The available specimens of Acrididae from northern Oklahoma in the

* Contribution from the Dept. of Zoology, University of Oklahoma no. 189.

University of Oklahoma Museum have also been considered. However, the greater part of the museum collection is being studied elsewhere.

These collections represent the following twenty-six counties in northern Oklahoma: Cimarron, Texas, Beaver, Harper, Ellis, Woodward, Woods, Alfalfa, Grant, Garfield, Kingfisher, Kay, Noble, Osage, Pawnee, Payne, Washington, Tulsa, Nowata, Rogers, Craig, Mayes, Cherokee, Ottawa, Delaware, and Adair.

It is obvious from the descriptions of the vegetational, physiographic, and climatic characteristics of Oklahoma that there is a great variety of habitats in northern Oklahoma (Bruner, 1931).

List of Species

In the following list an attempt has been made to include all records of species from northern Oklahoma and such information as regional distribution, indicated by the counties in which species have actually been taken, seasonal range (actual dates of collections are sometimes given, also), "peak seasonal" records, and local distribution. The faunal area is generally indicated. Species listed by Blair and Hubbell (1938) are indicated by "B and H" to avoid repetition. Surrounding regions in other states where species have been taken are recorded.

Acrydiinae

Acrydium ornatum Say.—June, July, and August. Payne, Pawnee, Mayes, and Nowata counties. It is believed that this Acridian does not reach farther west than Payne County in Oklahoma. Caudell (1902) reports one male from Stillwater, Oklahoma. This insect occurs in northeastern Kansas and parts of Texas.

Acrydium arenosum angustum Hancock.—One male was collected August 9, 1932, in Ottawa County. This species is replaced in Kansas by the northern race *arenosum arenosum* (Burmeister). Isely (1905) reported the latter as synonymous with *Tettix obscurus*, as also did Tucker from a specimen in Douglas County, Kansas (1907). In 1907 Morse recorded this species from McAlester, Oklahoma, which is its known western limit.

Paratettix cucullatus cucullatus (Burmeister).—Washington, Nowata, Craig, Ottawa, Delaware, Pawnee, and Payne counties. This grouse locust, usually found in damp habitats, may be collected throughout most of the year. Records show *cucullatus* to inhabit eastern Kansas and northeastern Texas. Previous Oklahoma material has been determined as intermediate between *cucullatus* and *texanus*. *P. c. texanus* is a more southern race. There are very few differences between them.

Tettigidea lateralis lateralis (Say).—Washington, Craig, Rogers, Mayes, Nowata, and Ottawa counties. Caudell reports *lateralis* from Payne County (1902). This locust is more frequent in southeastern and central Oklahoma. It also occurs in northeastern Texas.

Acridinae

Mermiria neomexicana (Thomas).—July and August. Payne County, Oklahoma (Caudell, 1902). B. & H.

Mermiria bivittata (Serville).—This species was generally confused with *maculipennis* Bruner until Rehn's revision (1919) of the genus. Perkins, Payne County (Caudell, 1902). B. & H.

Mermiria maculipennis macclungi Rehn.—In the collections were more than three hundred specimens of this grasshopper recorded from Osage, Grant, Pawnee, Beaver, Woodward, Alfalfa, Noble, Texas, Woods, Payne, Harper, Kay, Ellis, Washington, Okmulgee, and Kingfisher counties.

There is a gradual transition between *maculipennis maculipennis* and *maculipennis macclungi* Rehn. The northwestern series is more closely *m. maculipennis*, while the northeastern variety is nearer *macclungi*. This is by far the most common Mermiria in Oklahoma.

The three species last mentioned have caused taxonomists much difficulty. Regarding this, Blatchley says (1920, p. 207):

> The three forms, *bivittata*, *maculipennis* and *macclungi*, are very closely related and were it not that McClung has shown the chromosomes of the first two named to be different, I should place them as did Scudder (1899) as one widely distributed and variable species under the name of *bivittata* Serv.

Mermiria picta (Walker).—Recorded from northern Oklahoma by Caudell (1902). Morse states that this species is found among coarse grasses in the vicinity of streams, and in prairie meadows. Uvarov (1928) gives *picta* as a synonym of *M. alcaris* Scudder.

Acrolophitus hirtipes (Say).—July and August. Cimarron, Harper, Woods, and Alfalfa counties. Thirteen of the specimens from Cimarron County are strikingly maculate, which is probably due to the immediate environment. B. & H.

Syrbula admirabilis (Uhler).—July, August, and September. Osage, Woods, Payne, Okmulgee, Harper, Pawnee, Noble, Alfalfa, Texas, Ellis, Kay, and Grant counties. This species reaches the peak of its abundance in late August. The northern limits of distribution are New Jersey and Pennsylvania. It also occurs in Texas and New Mexico. Payne County (Scudder, 1902).

Syrbula fuscovittata (Thomas).—September and October. B. & H.

Opeia obscura (Thomas). Latter part of August. B. & H.

Amphitornus coloradus coloradus (Thomas).—Cimarron, Texas, Harper, Woods, and Alfalfa counties. This species reaches its peak of abundance in the middle of July. All gradations occur from those in which the pronotum has supplementary carinae with light median line of a paler color to those of a solid, dark brown pronotal disk.

Eritettix simplex (Scudder).—March 12 to July 15, 1933. Apparently more abundant in central than in western Oklahoma. The writer has collected fifty-three specimens in the vicinity of Norman, Oklahoma. B. & H.

Phlibostroma quadrimaculatum Thomas.—June, July, and August. B. & H.

Orphulella pelidna (Burmeister).—Osage, Pawnee, Adair, Noble, Texas, Grant, Payne, Harper, and Alfalfa counties. This species has a very general distribution, although it is very infrequent in some parts of northern Oklahoma. The majority of specimens were taken in Pawnee and Osage counties. Reported from western Kansas and parts of Texas (Hebard, 1931).

Orphulella speciosa (Scudder).—Cimarron, Texas, Beaver, Harper, Alfalfa, Grant, Kay, Osage, Pawnee, Payne, and Okmulgee counties. This species has a wide distribution and can be collected from May to December. It is found in several variations, as reported by Hebard (1932), some of which are very striking because of their brilliant color and ecause of differences of the angle of the pronotal lateral carinae. Widely distributed outside of Oklahoma.

Dichromorpha viridis (Scudder).—August. B. & H.

Ageneotettix deorum (Scudder).—Cimarron, Texas, Beaver, Harper, Ellis, Woods, Woodward, Alfalfa, Kingfisher, Noble, Pawnee, Osage, and Nowata counties. This western species is known as east as Illinois and Indiana in the river valleys and plains where the soil is sandy. Reported as frequent from Kansas and Texas.

Psoloessa texana Scudder.—June. B. & H.

Boopedon nubilum (Say).—B. & H.

Boopedon maculatum Caudell.—June to August. Woods, Alfalfa, Grant, and Garfield counties, in prairie and pasture. This species is more common in Texas and southern Oklahoma than in northern Oklahoma and Kansas.

Boopedon auriventris McNeill.—B. & H.

Aulocara elliotti (Thomas).—June, July, and August. Hubbell (1926) states that *elliotti* is a "campestrian species ranging from British Columbia, Alberta and North Dakota to Mexico and California." There are variations in this series from a pale cross-shaped pronotal marking to a plain pronotal disk with indistinct marking. B. & H.

Arphia sulphurea (Fabricius).—June and July. B. & H.

Arphia conspersa Scudder.—B. & H.

Arphia xanthoptera (Burmeister).—July 3 to September 5. Harper, Ellis, Osage, Alfalfa, Payne, and Delaware counties. This species has a discontinuous distribution in northern Oklahoma. "The range of *xanthoptera* extends from southern New England, where it is common, west to Minnesota and western Nebraska, and south and southwest to central Florida, Oklahoma, and northern Texas." (Blatchley, 1920). Hebard (1931) reports *xanthoptera* in southern and eastern Kansas.

Arphia simplex Scudder.—June 5 to August 20. Beaver, Harper, Ellis, Grant, Garfield, Pawnee, Osage, Washington, Okmulgee, Craig, and Ottawa counties. The remaining counties had an average of two or three specimens.

Hebard (1931) states that *simplex* has been taken in South Dakota, Nebraska, Kansas, Texas, Utah, and Colorado. Caddo County (Morse, 1907).

Chortophaga viridifasciata (DeGeer).—April 13 to August 24. Harper, Ellis, Alfalfa, Grant, Kay, Noble, Payne, Pawnee, Osage, Washington, Nowata, and Ottawa counties. This species is generally distributed over most of Oklahoma. The majority of females are green, and most of the males are brown. There is a small percentage of brown females and green males. Texas, Mexico, Kansas, and in the eastern states.

Encoptolophus pallidus subgracilis Caudell.—July and August. B. & H.

Encoptolophus costalis (Scudder).—July 19 to August 18. Woods, Texas, and Grant counties. It is an occasional species found in dry, short grasses, and occurs in the Great Plains region of western Kansas and Texas. This is the first report of *costalis* from Oklahoma.

Hippiscus rugosus (Scudder).—July 15 to September 20. Texas, Harper, Woods, Alfalfa, Grant, Noble, Payne, Pawnee, and Osage counties. Four males and seven females have a pink wing disk while the remainder have the yellow wing disk. This species has a general distribution throughout the Great Plains, i.e., Kansas, Nebraska, Iowa, Illinois, Texas, and Colorado.

Pardalophora apiculata (Harris).—Cherokee Nation, Indian Territory (Caudell, 1902). The southwestern limit in the distribution of this northern species is Wheeler County in the Panhandle of Texas (Hebard, 1931).

Pardalophora phoenicoptera (Burmeister).—May 15 to August 1. Beaver, Payne, Pawnee, Nowata, Craig, Ottawa, and Adair counties. Southeastern United States, eastern Kansas, and Texas.

Pardalophora haldemanii (Scudder).—June 23 to August 15. Cimarron, Alfalfa, Noble, and Osage counties. Two males and two females have the pink wing disk while the remaining four have the yellow wing disk. Apparently, the yellow wing disk is characteristic of the western species. This species is abundant in Kansas but has not been reported from Texas.

Pardalophora saussurei (Scudder).—June 3 to August 31. Cimarron, Beaver, Ellis, Woodward, Alfalfa, Kingfisher, Noble, Pawnee, and Ottawa counties. This species is rare in Kansas but more common in Texas. Mangum, Oklahoma (Hubbell, 1926).

Xanthippus corallipes pantherinus (Scudder).—Cimarron, Beaver, Ellis, Harper, Woods, and Woodward counties. This attractive, large grasshopper is an upland prairie species and is found in Kansas and Texas. It reaches its peak of abundance about the first of June. It seems to intergrade with *c. latefasciatus* in western Oklahoma. The writer, however, finds *pantherinus* extending into the Panhandle.

Xanthippus corallipes latefasciatus Scudder.—B. & H.

Dissosteira carolina (Linnaeus).—This is perhaps the most common grasshopper in northern Oklahoma, and was collected in every county where collections were made. It is very common along the roadsides and in waste areas.

The specimens in the collections have been taken during June, July, August, and September. Blatchley (1920) states: "The distribution of *D. carolina* is as wide as that of any other of our locusts, being practically coxetensive with America north of Mexico." (P. 273).

Dissosteira longipennis (Thomas).—June 7 to September 14. Cimarron, Texas, Harper, Ellis, Grant, Pawnee, and Alfalfa counties. This is a western species reaching its eastern limit at Pawnee, Oklahoma. Nebraska, Kansas, and Texas. Perkins, Payne County (Caudell, 1902).

Spharagemon bollii Scudder.—June 6 to August 8. B. & H.

Spharagemon collare (Scudder).—June 25 to August 17. Cimarron, Texas, Beaver, Harper, Ellis, Woods, Alfalfa, Grant, and Delaware counties. Found throughout the Great Plains region, i.e., common in Texas, Kansas, Colorado, and Montana.

Spharagemon equale (Say).—Collected July 10 and 22 in Cimarron and Texas counties. Kansas and Texas.

Trachyrhachis kiowa kiowa (Thomas).—June 23 to August 15. B. & H.

Mestobregma plattei plattei (Thomas)—June 24 to August 23. B. & H.

Metator pardalinus (Saussure).—June 21 to July 22. Cimarron and Texas counties. This is a western plains species. It does not occur in Texas but is abundant in western Kansas (Hebard, 1931).

Psinidia fenestralis fenestralis Stål.—July and August. Beaver, Harper, Woodward, Alfalfa, and Delaware counties. This is the first record of this species from Oklahoma, although it occurs in Kansas. Usually found on sandy soil.

Trimerotropis pallidipennis pallidipennis (Burmeister).—June 13 to August 20. B. & H.

Trimerotropis pallidipennis salina Bruner.—August 3 and August 12. B. & H.

Trimerotropis saxatilis McNeill.—July 20, 1933. B. & H.

Trimerotropis citrina Scudder.—July to September. Cimarron, Texas, Beaver, Ellis, Alfalfa, Noble, Payne, and Pawnee counties. Common in southeastern United States. Reported also from Indiana, Nebraska, Kansas, Texas, and New Mexico.

Trimerotropis agrestis McNeill.—This species reaches its peak of abundance about August 1. B. & H.

Trimerotropis pistrinaria Saussure.—July 12 to July 26. B. & H.

Trimerotropis laticincta Saussure.—June 13 to October 18. B. & H.

Trimerotropis cincta (Thomas).—Stillwater (Caudell, 1902 and Hubbell, 1926). It is a northern Great Plains species, occurring in Colorado, New Mexico, and northwestern Nebraska. In the writer's opinion, this is an

erroneous record, as *cincta* is not expected to be in Oklahoma. If present, it would be more likely in the western part of the State.

Hadrotettix trifasciatus (Say).—Ellis, Cimarron, Texas, Beaver, Harper, Woods, Alfalfa, Payne, Pawnee, Osage, Nowata, and Delaware counties. Apparently common in Oklahoma, Kansas, and Texas.

Batrachotetriginae

Brachystola magna (Girard).—Collected during July and August in Cimarron, Texas, Beaver, Harper, Ellis, Woodward, Woods, Alfalfa, Grant, and Kay counties. Common in western Kansas and Texas.

Cyrtacanthacrinae

Leptysma marginicollis (Serville).—April 10 to July 1. Cimarron, Beaver, and Alfalfa counties. The writer believes this to be a western record for this marsh species. Not reported by Hubbell (1926). Eastern Kansas, Texas, and many of the eastern states.

Schistocerca damnifica damnifica (Saussure).—July. B. & H.

Schistocerca americana americana (Drury).—May to November. Payne, Craig, Noble, Osage, Kingfisher, Washington, Woodward, Alfalfa, Delaware, Grant, and Nowata counties. Woodward County is the western limit of known distribution of *americana*. Eastern United States. It is one of the largest of our locusts.

Schistocerca lineata Scudder.—Cimarron, Texas, Beaver, Harper, Ellis, Woodward, Woods, Alfalfa, Garfield, Noble, Payne, Pawnee, and Osage counties. This species reaches its peak of abundance in the middle of August. There is a question about the relationship and taxonomic difference between *lineata* and *alutacea*. *S. alutacea* is an eastern species. Hubbell (1926) reports two races of *alutacea* in Oklahoma. Hebard believes *alutacea* to be referable to *lineata*. Until a generic revision can be made, the writer will use the specific name *lineata* as has been done for the Kansas material (Hebard, 1931). Isely (1935) determined the specimens in the collection as *alutacea*.

Schistocerca obscura (Fabricius).—Texas, Harper, Woodward, Alfalfa, Kay, Noble, Payne, Osage, Washington, and Delaware counties. It reaches its peak of abundance in August. Texas, Mexico, Kansas, and many of the eastern states. Caddo, Oklahoma (Morse, 1907).

Hypochlora alba (Dodge).—July and August. B. & H.

Campylacantha olivacea olivacea (Scudder).—August, September, and October. Alfalfa, Osage, Beaver, Woodward, Ellis, Noble, Texas, Harper, Cimarron, Woods, Pawnee, and Payne counties. The large majority of these specimens are from Beaver, Harper, Woods, and Alfalfa counties. Blatchley says it "ranges from Illinois, and Georgia west to Nebraska and southeastern Colorado, and southwest through Kansas and Oklahoma to Fort Worth, Texas."

Campylacantha olivacea vivax (Scudder).—August. B. & H.

Aeoloplus turnbulli plagosus (Scudder).—June, July, and August. Cimmarron, Beaver, Harper, Ellis, and Woods counties. A western species. Texas and Colorado. The writer believes this to be the first report of the species in Oklahoma since Hubbell (1926) failed to report it.

Hesperotettix viridis viridis (Thomas).—June 29 to July 16. Alfalfa, Major, Grant, Kay, Garfield, and Pawnee counties. This is a Great Plains species and is generally distributed throughout central Oklahoma, Kansas, and Texas.

Hesperotettix speciosus (Scudder).—July, August, and September. Woods, Alfalfa, Major, Garfield, Noble, and Osage counties, the Great Plains region of northern Oklahoma. The organs of flight in all of these specimens are almost fully developed. In a few of the specimens the carinal line on the pronotum is not distinguishable by the red color.

Melanoplus beameri Hebard.—This short-winged prairie form is abundant from April to late June. B. & H.

Melanoplus scudderi latus Morse.—August and September. Kay, Osage, Pawnee, Washington, Rogers, Craig, and Nowata counties. This species is common in eastern Kansas and has a tendency to vary toward *scudderi scudderi* in Texas.

Melanoplus texanus (Scudder).—This short-winged Melanoplus is abundant from April until late June. B. & H.

Melanoplus discolor (Scudder).—Most abundant late in July. B. & H.

Melanoplus glaucipes (Scudder).—July. B. & H.

Melanoplus differentialis (Thomas).—This collection represents all counties in northern Oklahoma with the exception of Craig, Ottawa, Mayes, Delaware, Cherokee, and Adair. One of the most common grasshoppers of the *Melanoplus* group. It tends toward a yellow color. Very few are of the black color phase. Found over most of the United States.

Melanoplus bivittatus (Say).—This collection represents every county in northern Oklahoma in which collections have been made. It reaches its peak of abundance late in July. Isely (1935) reports this species as rare in Texas. Kansas and most of the states north and east.

Melanoplus ponderosus viola (Thomas).—July 16. B. & H.

Melanoplus punctulatus (Scudder).—Alfalfa County. This is the western known point in its range.

Melanoplus confusus Scudder.—May 4 to June 3. Woods, Grant, Alfalfa, Major, Noble, and Pawnee counties. Common in Kansas and Texas. Payne County (Hubbell, 1925).

Melanoplus femur-rubrum femur-rubrum (DeGeer).—Cimarron, Craig, Osage, Alfalfa, Woods, Ellis, Noble, Delaware, Texas, Washington, Payne, and Woodward counties. Relatively rare in northern Oklahoma, although

apparently widely distributed. Isely (1935) reports it as rare in Texas and the writer has never collected it in southern or central Oklahoma.

Melanoplus lakinus (Scudder).—Cimarron County. Latter part of July. B. & H.

Melanoplus impudicus Scudder.—B. & H.

Melanoplus fasciatus (F. Walker).—July 14. B. & H.

Melanoplus mexicanus mexicanus (Saussure).—Collected in all counties in northern Oklahoma in which collections were made. It reaches its peak of abundance in late September. The migratory phase *spretus* has not been reported from Oklahoma. Eastern states as well as throughout the Great Plains.

Melanoplus keeleri luridus (Dodge).—September 10 to October 29. Woods, Garfield, and Osage counties. Throughout Kansas (Hebard, 1931).

Melanoplus packardii Scudder.—June 30 to August 30. Beaver, Ellis, Pawnee, Woods, Osage, Harper, and Cimarron counties. Minnesota, Iowa, Kansas, and Texas.

Melanoplus foedus foedus Scudder.—July and August. Usually confused with *packardii* because of their general similarities in appearance. B. & H.

Melanoplus angustipennis (Dodge).—July and August. Ellis, Kingfisher, Alfalfa, Noble, Texas, Pawnee, and Harper counties. Southern Kansas, but previously not recorded from Oklahoma.

Melanoplus impiger (Scudder).—July, August, and September. Beaver, Alfalfa, Pawnee, Noble, Payne, Harper, Ellis, Tulsa, Osage, and Grant counties. Over half of these specimens are from Alfalfa County and most of the remainder are from Pawnee. Hebard (1931) doubts the validity of this species. It is perhaps a geographic race of *angustipennis*. Minnesota, Iowa, Kansas, and Texas.

Melanoplus flavidus flavidus Scudder.—June, July, and August. Harper, Ellis, Alfalfa, Woods, and Beaver counties. A western species, not extending to eastern Oklahoma. Hebard (1931) states that it reaches southern Canada in its northern distribution.

Melanoplus bowditchi bowditchi Scudder.—B. & H.

Dactylotum pictum (Thomas).—August 1 to September 2. B. & H.

Discussion

The Acrididae of northern Oklahoma are not limited in their distribution to a specific food plant, but are distributed according to the general type of vegetation, such as forest, shrubbery, tall grass, short grass, or marsh. There are many species which inhabit only a narrow area with definite natural features. Many of the species are not so restricted, and occupy more widely varying regions.

Over a period of thirty years the Great Plains area of western Oklahoma shows an average annual rainfall of 21.6 inches; an average temperature of 56.4°; and an average growing season of 192 days. The average altitude is 2,820 feet. The low precipitation, the short growing season, and the high altitude are among the environmental factors which may limit some of the Oklahoma species of Acrididae to this region.

Of the typical Great Plains Acrididae, six species reach their eastern limit of distribution before reaching the eastern border of the Great Plains. It is probable that these species are more narrowly limited by environmental conditions. At the eastern edge of the Great Plains the precipitation is approximately forty per cent greater and the altitude is approximately forty per cent less than the average for the region. The species are *Arphia conspersa, Xanthippus c. latefasaciatus, Melanoplus lakinus, Spharagemon equale, Metator pardalinus* and *Campylacantha o. vivax.*

Twenty-four species in the collection are confined to the Great Plains region. The writer has included columns 1, 2, 3, 4, and 5 of the distribution chart in this estimate because of the indefiniteness of the Great Plains boundary. Columns 4 and 5 indicate the zone of intergradation between the Acrididae of the Great Plains and those of the central prairie plains. This zone is inhabited by a greater number of species because of the overlapping of plains and prairie forms.

The central prairie plains have an average annual precipitation of 29.8 inches; an average temperature of about two degrees higher than that of the Great Plains; and an average growing season of 206 days. Tall grass is characteristic of the central prairie plains and the environment enables certain species, not found in the Great Plains, to thrive. Uvarov has expressed the idea that the height of the vegetation is the most important factor in determining the distribution of Acrididae. He states (1928, p. 93) that "Vegetation apparently acts as a microclimatic factor, owing to the shade produced influencing evaporation." In this discussion is also a statement that Acrididae may be segregated largely into groups, some of which exist almost entirely on the bare ground, and some of which live on taller vegetation. Some species are ordinarily found at definite levels on the vegetation.

Several species do not appear outside of the central plains. These species are: *Melanoplus bowditchi, Melanoplus punctulatus, Psoloessa texana, Hypochlora alba, Encoptolophus subgracilis, Dichromorpha viridis, Mermiria picta, Boopedon auriventris, Melanoplus p. viola, Melanoplus impudicus, Melanoplus fasciatus, Mermiria bivittata,* and *Trimerotropis saxatilis.* Some of the species listed above are rare and the writer does not intend to indicate the limits of the distribution of a species where adequate numbers do not appear, but to show that certain species are limited, so far as this study is concerned, to certain localities. The numbers of each species taken, with the exception of the more difficult Melanopli, are listed in a column adjacent to the species names on the chart. Among the Melanopli in most cases the number refers to the number of males in the collection.

This group of central prairie plains species intergrades in the west with the Great Plains species, which has been discussed previously. In the east these species overlap with the mixed timber and prairie group (Column 8 of Chart). As was the case with the eastern boundary of the Great Plains, the eastern boundary of the central prairie plains shows a large number of species, because of the intergrading of the plains and timber forms.

Some Acrididae are more plastic in their environmental requirements and a large number are found throughout both the Great Plains and central prairie plains. *Dactylotum pictum* and *Brachystola magna* are western plain species which have reached well into the central prairie plains. *Hadrotettix trifasciatus* is another Great Plains species which has extended eastward. Some other species which have become adapted to short and high grasses are: *Encoptolophus costalis, Trachyrhachis k. kiowa, Schistocerca lineata, Campylacantha o. vivax, Hesperotettix v. viridis, Dissosteira longipennis, Aulocara elliotti, Melanoplus packardii, Pardalophora haldemanii, Hippiscus rugosus, Melanoplus angustipennis,* and *Syrbula fuscovittata.*

East of the central prairie plains area is the mixed timber and plains region. The annual rainfall is over forty inches and the average altitude is only 763 feet. So far as the records indicate there is no material difference in temperature from that of the central prairie plains. The timber grasshoppers and grouse locusts are characteristic of this region of northern Oklahoma. The grouse locusts of northern Oklahoma are eastern species and prefer a moist habitat.

Six species in northern Oklahoma are not found outside of this area. They are: *Arphia sulphurea, Pardalophora phoenicoptera, Tettigidea l. lateralis, Pardalophora apiculata, Schistocerca o. damnifica,* and *Acrydium a. angustum.* These species are distributed eastward in Arkansas and Missouri.

Some of the northern Oklahoma Acrididae occupy both the central prairie and woodland areas. These are *Melanoplus texanus, Melanoplus bispinosus, Melanoplus beameri, Melanoplus s. latus, Acrydium ornatum, Paratettix c. cucullatus,* and *Spharagemon bollii.* Of somewhat greater plasticity are a few species which extend from the woodland area into the eastern part of the Great Plains. *Psinidia f. fenestralis, Mermiria m. macclungi, Syrbula admirabilis, Orphulella pelidna, Schistocerca obscura,* and *Arphia simplex* extend almost entirely across northern Oklahoma. They are not, however, found in the western end of the Panhandle where the rainfall is approximately fourteen inches and the altitude approximately 4,000 feet.

There are several species in northern Oklahoma which extend from the eastern boundary of the State to the tip of the Panhandle. These are more independent species which are able to survive in the major environmental complexes of the region studied. These species occur in each of the states surrounding Oklahoma. They are: *Melanoplus bivittatus, Melanoplus m. mexicanus, Dissosteira carolina, Pardalophora saussurei, Melanoplus f. femurrubrum,* and *Sparagemon collare.*

At least as indicated by the records, some species are distributed in very local areas. *Leptysma marginicollis* is a marsh species which apparently is not

found elsewhere. *Hypochlora alba,* one of the typical Great Plains species which overlaps into the central prairie plains, is associated with sage. *Mestobregma plattei plattei* is collected in rocky outcrops. *Trimerotropis agrestis* is peculiar to sand areas and is rarely found elsewhere.

Extensive field work is necessary, particularly in eastern Oklahoma, to determine the peculiarities of the more locally distributed forms. Records from surrounding states indicate that many more species are to be found in the shrubbery and along the creeks. The species of western Oklahoma are better understood as most of the Great Plains species expected, on the basis of other studies, are represented.

From the chart of distribution it is seen that many species may be grouped according to their eastern limits of distribution in the same localities. This would indicate that there are some environmental barriers which tend to limit the species in its eastward distribution. The writer has discussed distribution from west to east instead of east to west because of the larger number of western species in the collection.

Thirteen species reach their eastern distribution at the eastern boundary of Alfalfa County (between columns 5 and 6 on chart). This is also the eastern boundary of the Great Plains region. The limiting factor is probably the height of the grass. The Great Plains area is characterized by short grass, while east of Alfalfa County are the central prairie plains with taller grass. Precipitation is materially greater east of Alfalfa County.

Thirteen species reach their eastern distribution in northern Oklahoma at the eastern boundary of Kay County (between columns 7 and 8 on chart). This is the western boundary of sandstone hills region and the Oak Hickory Savannah. These species are able to live in the environment of Kay County, which is the red-bed plains and *Stipa-Koeleria* association, but probably are not plastic enough to exist also in the sandstone hills region.

Twenty species reach their eastern distribution near the eastern boundary of Pawnee County (between columns 8 and 9 on chart). This is the boundary between the central prairie plains and the mixed timber and prairie. The limiting factors in this region, other than vegetation, are rainfall and possibly altitude. East of Pawnee County the rainfall increases about five inches per year with a steady increase eastward. The altitude is approximately four hundred feet lower.

Ten species reach their eastern distribution in northern Oklahoma at the edge of the Ozark Mountains (between columns 9 and 10 on chart). This is to be expected in this area because of the presence of the Oak-Hickory forest. In this region most of the timber species of northern Oklahoma are found. A change from tall grass to forest would naturally be prohibitive to a majority of the less plastic species.

Some of the species discussed as reaching their eastern limits in Oklahoma are found in other states east. There are several reasons for this apparent

incoherence. Many of the species are localized in habitat and are distributed irregularly throughout the United States. In some cases the number of specimens is too small to be significant in indicating limits of distribution.

Summary

I. The Acrididae of northern Oklahoma are not limited in their distribution to any specific food plant, but according to general types of vegetation.

II. A greater number of species is found in the vicinity of the boundaries of vegetation areas than in the typical areas themselves, because of an overlapping of species. Approximately thirty-six species have been collected from the Great Plains region and thirty-eight species from the central prairie plains region. In the zone between these two regions, fifty-one species have been taken. Twenty-three species have been determined from the mixed timber and prairie region. On the eastern boundary of the central prairie plains and the western boundary of the mixed timber and prairie, forty-six species have been collected.

III. Ninety-two species are reported from northern Oklahoma.

REFERENCES

Blair, W. Frank and T. H. Hubbell. 1938—The Biotic Districts of Oklahoma. Amer. Midl. Natur. **20**:425-454, 1 text fig.

Blatchley, W. S. 1903—The Orthoptera of Indiana. 27th Ann. Rep. Ind. Dept. of Geol. and Nat. Resources, pp. 123-471.

———1920—Orthoptera of North-eastern America. Indianapolis.

Brimley, C. S. 1908—Notes on the Orthoptera of Raleigh, North Carolina. Ent. News **19**:16-21.

Bruner, Lawrence. 1890—New North American Acrididae Found North of the Mexican Border. Proc. U. S. Nat. Mus. **12**:47-82.

Bruner, W. E. 1931—The Vegetation of Oklahoma. Ecol. Mono. **1**(2):101.

Caudell, A. N. 1902—Notes on Orthoptera from Oklahoma and Indian Territory with Descriptions of Three New Species. Trans. Am. Ent. Soc. **27**:83-91.

———1903—Notes on Orthoptera from Colorado, New Mexico, Arizona and Texas, with Descriptions of New Species. Proc. U. S. Nat. Mus. **27**:775-809.

———1908—Notes on Some Western Orthoptera with a Description of One New Species. Proc. U. S. Nat. Mus. **34**:71-81.

———1915—Notes on Some United States Grasshoppers of the Family Acrididae. Proc. U. S. Nat. Mus. **49**:25-31.

——— and Morgan Hebard. 1912—Fixation of the Single Type (Lectotypic) Specimens of Species of American Orthoptera. Proc. Acad. Nat. Sci. Phil. pp. 157-168.

Fox, Henry. 1914—Data on the Orthopteran Faunistics of Eastern Pennsylvania and Southern New Jersey. Proc. Acad. Nat. Sci. Phil. pp. 441-534.

Hancock, J. L. 1902—The Tettigidae of North America. Chicago.

Hebard, Morgan. 1917—Notes on Mexican Melanopli. Proc. Acad. Nat. Sci. Phil. pp. 251-275.

———1925—The Orthoptera of South Dakota. Proc. Acad. Nat. Sci. Phil. **77**:33-155.

———1928—The Orthoptera of Montana. Proc. Acad. Nat. Sci. Phil. **80**:211-306.
———1929—The Orthoptera of Colorado. Proc. Acad. Nat. Sco. Phil. **81**:303-425.
———1930—The Orthoptera of Alberta. Proc. Acad. Nat. Sci. Phil. **82**:377-403.
———1931—The Orthoptera of Kansas. Proc. Acad. Nat. Sci. Phil. **83**:119-231.
———1934—The Dermaptera and Orthoptera of Illinois. Division of the Natural History Survey of the Dept. of Registration and Education of Illinois **20** (Article 3).

HUBBELL, T. H. AND A. I. ORTENBURGER. 1926—Notes on Oklahoma Orthoptera with a List of Species from the State. Proc. Oklahoma. Acad. Sci. **6**:149-183.

ISELY, F. B. 1935—Acridian Researches within Northeastern Texas (Orthoptera). Ent. News, Feb., March. pp. 37-43; 69-75.

MCNEILL, JEROME. 1901—Review of the Orthopteran Genus *Trimerotropis* Proc. U. S. Nat. Mus. **23**:393-449.

MORSE, A. P. 1904—Researches on North American Acrididae. Carnegie Institution of Washington Publ.
———1907—Further Researches on North American Acrididae. Carnegie Institution of Washington.
——— AND MORGAN HEBARD. 1915—Fixation of Single Type (Lectotypic) Specimens of Species of American Orthoptera (Described by Morse). Proc. Acad. Nat. Nat. Sci. Phil. pp. 96-106.

REHN, J. A. G. 1903—Notes on the Orthoptera of New Mexico and Western Texas. Proc. Acad. Nat. Sci. Phil. pp. 717-727.
———1904—Notes on Orthoptera from Arizona, New Mexico, and Colorado. Proc. Acad. Nat. Sci. Phil. pp. 562-575.
———1907—Notes on Orthoptera from Southern Arizona with Descriptions of New Species. Proc. Acad. Nat. Sci. Phil. pp. 24-81.
———1919—A Study of the Orthopterous Genus *Mermiria* Stål. Proc. Acad. Nat. Sci. Phil. pp. 55-120.
——— AND MORGAN HEBARD. 1908—An Orthopterological Reconnaissance of the Southwestern United States. Pt. I. Arizona. Proc. Acad. Nat. Sci. Phil. pp. 365-402. 1909. Pt. II. New Mexico and Western Texas. Proc. Acad. Nat. Sci. Phil. pp. 111-175.

SCUDDER, SAMUEL H. 1897—Revision of the Orthopteran Group Melanopli (Acrididae) with Special Reference to North American Forms. Proc. U. S. Nat. Mus. **20**:1-421.
———1900—Catalog of the Described Orthoptera of the United States and Canada. Proc. Davenport Acad. Nat. Sci. **8**:1-101.

THOMAS, CYRUS. 1873—Synopsis of the Acrididae of North America. Hayden's Rep. U. S. Geol. Surv. Terr. **5**:1-258.

UVAROV, B. F. 1928—Locusts and Grasshoppers. Imperial Bureau of Ent., London.
———1931—Insects and Climate. Trans. Ent. Soc. London **74**:1-247.

United States Weather Bureau Climatic Summary of U. S., 1931. Sections 42 and 43.

The columns 1-10 on the chart correspond in location in northern Oklahoma to the regions indicated on the following map. The number to the right of the specific name refers to the number of specimens of the species. The lower row of numbers are number of species in corresponding region. An asterisk preceding the specific name indicates that that species has not been reported previously in Oklahoma.

N.B. These species previous to Blair & Hubbell (1938) had not been reported from Oklahoma.

STATE OF OKLAHOMA

DISTRIBUTION CHART

		1	2	3	4	5	6	7	8	9	10
Arphia conspersa	1	x									
Xanthippus c. latefasciatus	7	x									
Melanoplus lakinus	4	x									
Sparagemon equale	4	x	x								
**Metator pardalinus*	41	x	x								
Campylacantha o. vivax	5	x	x								
Trimerotropis pistrinaria	5	x	x	x	x						
Trimerotropis p. pallidipennis	19	x	x		x						
Mastrobregma plattei plattei	7	x	x		x						
**Melanoplus discolor*	12		x	x	x						
Trimerotropis p. salina	3				x						
Opeia obscura	6				x						
Amphitornus coloradus	56	x	x	x	x	x					
Phlibostroma quadrimaculatum	35	x	x	x	x	x					
Trimerotropis citrina	36	x	x	x	x	x					
**Aeoloplus t. plagosus*	41	x		x	x	x					
Melanoplus f. foedus	14	x		x	x	x					
Xanthippus c. pantherinus	25	x		x	x	x					
**Leptysma marginicollis*	21	x		x		x					
Melanoplus glaucipes	5	x			x	x					
Acrolophitus hirtipes	28	x			x	x					
Melanoplus f. flavidus	13			x	x	x					
Melanoplus b. bowditchi	1					x					
Melanoplus punctulatus	1					x					
Psoloessa texana	2					x					
Encoptolophus costalis	3		x			x	x				
Boopedon maculatum	22				x	x	x				
Dactylotum pictum	55	x	x	x	x	x	x	x			
Brachystola magna	65	x	x	x	x	x	x	x			
Trachyrhachis k. kiowa	30	x	x	x	x						
Trimerotropis laticincta	6	x			x			x			
Eritettix simplex	5	x						x			
Mermiria neomexicana	40			x	x	x		x			
Trimerotropis agrestis	8			x				x			
Hypochlora alba	13					x	x	x			
Encoptolophus subgracilis	5						x	x			

		1	2	3	4	5	6	7	8	9	10
Dichromorpha viridis	7						x	x			
Mermiria picta	1							x			
Boopedon auriventris	1							x			
Trimerotropis cincta	1							x			
Schistocerca lineata	204	x	x	x	x	x	x	x	x		
Hadrotettix trifasciatus	92	x	x	x	x	x		x	x		
Campylocantha o. olivacea	139	x	x	x	x	x		x	x		
Hesperotettix v. viridis	64	x	x	x	x	x		x	x		
Dissosteira longipennis	31	x	x		x	x	x		x		
Aulocara elliotti	189	x	x		x	x			x		
Melanoplus packardii	57	x		x	x				x		
**Pardalophora haldemanii*	8	x				x		x	x		
Hippiscus rugosus	144		x	x	x	x	x	x	x		
**Melanoplus angustipennis*	28		x		x		x	x	x		
Syrbula fuscovittata	65			x	x	x	x	x	x		
Hesperotettix speciosus	94				x	x	x	x	x		
Melanoplus confusus	24				x	x	x	x	x		
Melanoplus k. luridus	12				x		x		x		
Hesperotettix v. pratensis	70					x	x	x	x		
Melanoplus p. viola	1								x		
Melanoplus impudicus	2								x		
Melanoplus fasciatus	7								x		
Mermiria bivittata	6								x		
Trimerotropis saxatilis	7								x		
Melanoplus differentialis	217	x	x	x	x	x	x	x	x	x	
Orphulella speciosa	140	x	x	x	x	x	x	x	x	x	
Ageneotettix deorum	362	x	x	x	x	x	x	x	x	x	
Boopedon nubilum	62	x			x			x	x	x	
Mermiria m. macclungi	321		x	x	x	x	x	x	x	x	
Syrbula admirabilis	114		x		x	x	x	x	x	x	
Chortophaga viridifasciata	154				x	x	x	x	x	x	
Melanoplus bispinosus	63					x	x	x	x	x	
Melanoplus texanus	10							x	x	x	
Melanoplus beameri	14							x	x	x	
Melanoplus bivittatus	378	x	x	x	x	x	x	x	x	x	x
Melanoplus m. mexicanus	188	x	x	x	x	x	x	x	x	x	x
Dissosteira carolina	234	x	x	x	x	x	x	x	x	x	x
Pardalophora saussurei	19	x		x	x	x	x	x	x		x
Melanoplus f. femur-rubrum	19	x	x		x	x		x	x	x	x
**Spharagemon collare*	169	x	x	x	x	x	x				x
Orphulella pelidna	83		x		x	x	x	x	x		x
Schistocerca obscura	146		x		x	x		x	x	x	x
Arphia simplex	34			x	x	x	x		x	x	x
**Psinidia f. fenestralis*	39			x	x	x					x
Schistocerca a. americana	76				x	x	x	x	x	x	x
Arphia xanthoptera	15				x	x		x	x		x
Melanoplus s. latus	62							x	x	x	x
Acrydium ornatum	24							x	x	x	x
Paratettix c. cucullatus	168							x	x	x	x
Spharagemon bolli	16							x	x		x
Arphia sulphurea	19								x	x	x
Pardalophora phoenicoptera	39								x	x	x
Tettigidea l. lateralis	55									x	x
Pardalophora apiculata	1									x	x
Schistocerca d. damnifica	4										x
Acrydium ar. angustum	1										x
		41	34	33	53	50	30	46	47	24	22

New Methods of Reporting Ecological Collections of Prairie Arthropods[1]

Martha W. Shackleford

In studies of animal ecology in which the emphasis is on the community, insects and other arthropods are of great importance. Many people accept without challenge the statement that this is the Age of Insects. Therefore, in describing and evaluating the forces that are at work in a particular community, one expects to find that insects and spiders are of great biotic significance.

In an effort to get an estimate of the numbers of arthropods present above the ground surface in a community, a sample of fifty sweeps with a sweep-net is often used. Many observers have found this method satisfactory for determining the presence of the abundant forms. Changes from season to season or between communities in amount and kind of arthropod life have been discovered by the use of the sweep-net sample. As in the early plankton work, the method, although it has its limitations, has proved valuable in mapping out large fluctuations. (For a summary, see Carpenter, 1936).

It has been the custom in examining the contents of the sweep-net to count and record the individuals found in the sample. In this study it is suggested that it might be better to count the number of milligrams or of cubic centimeters. For example, suppose one has a collection of 15 forms—twelve *Lygus praetensis* L. (a small Hemipteran) and three *Melanoplus confusus* Sc. (a grasshopper). It is suggested that it would be better to report milligrams of *Lygus* and milligrams of *Melanoplus* or cubic centimeters of each. In weight or cubic content the grasshoppers would greatly exceed the hemipterans although their numbers are few.

Davidson (1932), in speaking of sweep-net work on a woodland sere in central Illinois, said "This paper deals chiefly with arthropods of average size. Relative to this type it may be said that the biotic significance of an animal species within a community depends upon its abundance (having due regard to size) in relation to the total population." Following out her idea, in the present study arthropods are reported as milligrams or as cubic centimeters in order to get a value in which the biotic significance is more correctly represented than by the use of individual numbers.

Method

The unit of collection remained the same as in much previous work of this nature: for the herbs, 50 sweeps of a net of 14 inches diameter, and for the ground, the examination of a piece of sod 12 inches by 6 inches dug to a

1 Contribution from the Biology Laboratory of the Oklahoma College for Women.

depth of 3 inches. The sweeps and sod were examined in the laboratory of the Oklahoma College for Women. Total numbers in each collection were recorded as in previous studies of this nature. In addition, the total weight in milligrams was obtained for both herb and ground collections as soon after sorting as possible. The difficulty in getting an approximate weight was great because the arthropods were changing due to evaporation. After weighing, the insects were placed in 70 percent alcohol. At first most arthropods floated but shortly the tracheal system became filled with liquid and they sank to the bottom of the vial. Several months after the collections were made, the volumes were estimated. The contents of the vial including the submerged arthropods was poured into a graduate and volume in cubic centimeters read. The liquid was poured off the collection and its volume read. The difference gave the volume of the collection. The difficulty of the volume measurement method was that it necessitated emersing all forms in alcohol. Some specimens, such as Lepidoptera, are seriously harmed for identification purposes by this method. It was a more accurate method than that of weighing the collection.

Location

The area from which collections were made was a three acre tract of climax grassland about five miles west of the Oklahoma College for Women, Chickasha, Oklahoma. It was a part of the W. L. Dawson farm. The grass had been used for prairie hay with occasional light winter grazing. The area had not been plowed or burned during the 41 years in which it had been occupied by its present owner. It was a well-drained, west-facing slope. The principal grasses were the two species of *Andropogon, furcatus* and *scoparius*. It was a sample of the climax *Andropogon-Bison-Canis* (tall grass prairie) Association (Carpenter 1939, p. 82) in-so-far as an area can be considered climax without the larger mammals.

Methods of Reporting Ground Collections

The three graphs in Fig. 1 show a single set of weekly collections measured in three ways: by volume, by weight, and by the number of individual animals present.

The curves for volume and for weight are closely similar. At no time is there a peak in one and a depression in the other. On three occasions the directions of the curves was not the same—November 1, January 11, and August 25. A collection might have a marked increase in weight due to a number of Carabid beetles with heavy coverings, without any great increase in volume as compared with the previous collection.

In contrast to this similarity between data as represented in cubic centimeters or in milligrams, the curve showing total numbers of individuals varied in form from the other curves. On November 14. the number of individuals was only slightly greater than for the previous collection, but both the weight and the volume showed a marked increase. In this collection, there were a number of maybeetle *(Phyllophaga)* larvae. Recorded as individuals, they

were not numerous enough to cause much increase over the total of the previous week, but they weighed and bulked large. On the other hand, on June 6, the number of individuals was high because of a large number of eggs probably beetle eggs, found in the soil sample. The weight and volume curve was not greatly influenced by these diminutive eggs, but the numbers curve went up.

For the ground collections, a more complete picture is obtained if total numbers per collection are supplemented by either total weight or total volume per collection. Either weight or volume would be sufficient, since the data from this year of collecting showed the two curves to be similar.

Methods of Reporting Herb Collections

An analysis of the herb collections by week, Fig. 2, compared also the weight, volume, and numbers in each herb collection. As in the ground collec-

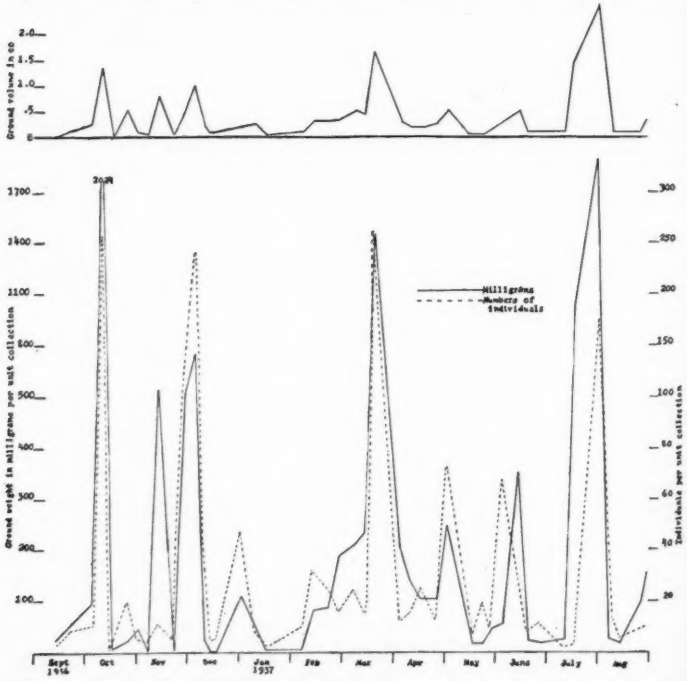

Fig. 1. Graph showing the weekly invertebrate ground population of one-half square foot of sod, dug to a depth of three inches, in a mid-Oklahoma climax prairie, Sept. 13, 1936 to August 31, 1937. Each sample is recorded in three ways—as cubic centimeters, as number of individuals, and as milligrams.

tions, the correspondence was close between the curve for weight in milligrams and for volume in cubic centimeters. There were differences; for example, on October 25 the weight had increased due to a number of Collembola and of ants, while the volume had not increased. Ants are heavier in proportion to their volume than are most other insects.

In contrast to this similarity which was generally observed between weight and volume curves, the curve showing individual numbers was at times oppo-

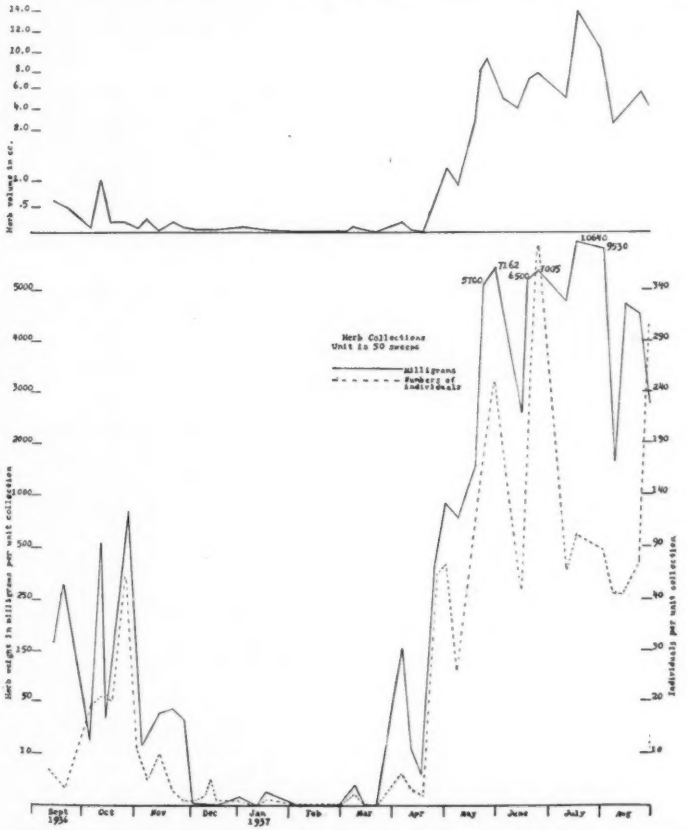

Fig. 2. Graph showing weekly arthropod herb populations obtained by sweep-net samples, from a mid-Oklahoma climax prairie, Sept. 13, 1936 to August 31, 1937. Each sample is recorded in three ways—as cubic centimeters, as number of individuals, and as milligrams.

site in direction from the other curves and at such times created an exactly opposite picture of the week-by-week trend in amount of arthropod life. This was seen clearly in the late summer period.

An example of the dissimilarity of the weight and the numbers curves is seen in the last two entries on the lower graph (Fig. 2). On the next to the last collection, there were 75 individuals but the weight was high because these included ten grasshoppers, one walking-stick, twenty-five Hemiptera, and one large spider (*Metargiope trifasciata* F.). On the following week of the last collection, the numbers curve had gone up to 306 individuals, but the weight was less because the collection had included 173 Collembola (family Sminthuridae) which are of small size.

According to numbers of individuals there was a late summer decline followed by a recovery in amount of arthropod life in the autumn. According to the weight or volume curves, no late summer decline occurred. This disparity in the impression conveyed indicated the value of working out either a weight or a volume curve in community studies of arthropod abundance.

A Quantitative Standard for Determining Arthropod Influents

In preliminary studies of an animal community, a list of predominants abundant forms) is usually compiled. The term predominant is explained by Bird (1930): "A general term, predominant, like community, should be used, for those animals of outstanding abundance or conspicuous influence in the community . . . whose exact importance is not known."

When more is known about the life of the community, some of the predominants are designated influents. Influents are defined "as animals having very obvious effects on the plants and animals of the community and on the habitat," according to Shelford and Olson (1935) who listed seven climax insect influents for the transcontinental coniferous forest of North America.

It is not always easy to tell what predominants have sufficient effects to warrant calling them influents. Certain species may be conspicuous in the collections but upon observation no serious damage seems to be attributable to them. They operate to maintain the equilibrium which characterizes the community. A study of the literature fails to reveal much information about their food relationships unless they happen to be economic pests. Davidson (1932) said:

> Food chains and food relations have usually been emphasized in the evaluation of species in communities. Food data are usually obtained from the literature. The basis of the records for the larger species lies in haphazard observation of stomach contents of specimens of unknown community relations. For the smaller species reports of food habits result from the observation of one species occurs and too often applied to related forms by inference. The literature concerned with the species treated in this paper was of little value. Exact information as to the food habits of the species found important hardly exists and time spent in searching for such information appeared wasted.

By comparing the volumes as well as numbers of the predominants, it would appear that an objective criterion might be worked out for the selection of the influents of a community. With such an idea in mind the following definition of influent was drawn up for the present data: An arthropod herbal influent is an arthropod which has a cubic content of one-half cubic centimeter or over in at least one herb collection or whose total number in one herb collection is twenty individuals or over. Seventeen arthropods were found to come within these limits.

The list of Influents for the climax, mid-Oklahoma prairie included eight Orthoptera, two Arachnida, one each leafhopper, ant, fly, Hemiptera and Collembola. Also included is an unidentified group of Orthoptera nymphs, probably in the main young stages of the adult Orthoptera included in the list. Specific identifications might eliminate the mites entirely or the chloropid fly, by showing that no one species came up to the qualification of a minimum of twenty individuals in a single collection. The list included only arthropods taken in the sweep-net; no ground forms were included. The list has the virtue of being a quantitative evaluation.

Arthropod Influents of the Herb Stratum of a Climax *Andropogon-Bison-Canis* (tall grass prairie) Association

The list includes all arthropods taken in the sweeps which totalled 20 or over in any one collection; or which had a volume of one-half c.c. or over in any one collection, provided that a total of at least three specimens was taken during the year.

Following the name of the arthropod are given the dates when the species was taken and in parenthesis after each date the number of individuals taken on that date, in a sample of fifty sweeps.

COLLEMBOLA

Sminthurus sp. August 31, 1937 (173).

ORTHOPTERA

Conocephalus fasciatus fasciatus (D.G.) and nymphs Sept. 13, 1936 (1), Oct. 18, 1936 (1), May 2, 1937 (1), May 16, 1937 (3), June 6, 1937 (2).

Melanoplus mexicanus mexicanus (Sanos.) Sept. 13, 1936 (1), Sept. 20, 1936 (1), May 23, 1937 (1), June 6, 1937 (1), June 19, 1937 (1), August 25, 1937 (2), August 31, 1937 (2).

Melanoplus confusus Sc. May 23, 1937 (5), May 31, 1937 (2), June 6, 1937 (4), June 13, 1937 (3), June 19, 1937 (2), June 25, 1937 (2), July 11, 1937 (1), July 18, 1937 (1), August 31, 1937 (2).

Melanoplus bivitattus (Say) July 11, 1937 (1), July 18, 1937 (1), August 13, 1937 (4).

Mermiria neomexicana (Thos.) and nymphs April 5, 1937 (1), June 19, 1937 (3), August 1, 1937 (4), August 13, 1937 (4).

Syrbula admirabilis (Uhl.) Nov. 8, 1936 (1), Nov. 14, 1936 (1), Nov. 22, 1936 (1), Nov. 29, 1936 (1), April 5, 1937 (1), May 23, 1937 (1), May 31, 1937 (1), August 1, 1937 (1), August 25, 1937 (5), August 31, 1937 (1).

Diapheromera velii velii Walsh (walking stick) May 23, 1937 (8), May 31, 1937

(1), June 6, 1937 (1), June 19, 1937 (3), June 25, 1937 (1), July 18, 1937 (6), August 1, 1937 (2), August 25, 1937 (2).

Diapheromera persimilis Cand. and Diapheromera nymphs. (walking stick) May 9, 1937 (1), May 16, 1937 (8), May 23, 1937 (4), May 31, 1937 (16), June 6, 1937 (2), June 19, 1937 (16), June 25, 1937 (7), July 11, 1937 (2), July 18, 1937 (12), August 1, 1937 (6), August 7, 1937 (4), August 31, 1937 (2).

Misc. grasshopper nymphs. Oct. 11, 1936 (1), April 11, 1937 (1), April 18, 1937 (1), April 26, 1937 (18), May 2, 1937 (1), May 9, 1937 (5), May 16, 1937 (8), May 23, 1937 (17), June 6, 1937 (1), June 25, 1937 (6), July 18, 1937 (1), August 1, 1937 (1), August 13, 1937 (5), August 25, 1937 (2), August 31, 1937 (1).

HEMIPTERA

Nysius californicus Stal. and nymphs Sept. 13, 1936 (20), June 13, 1937 (2), June 19, 1937 (8), June 25, 1937 (10), July 11, 1937 (29), July 18, 1937 (42), August 1, 1937 (28), August 7, 1937 (14), August 13, 1937 (6), August 25, 1937 (21), August 31, 1937 (48).

HOMOPTERA

Agallia sanguinolenta Prov. (leafhopper) April 26, 1937 (4), May 2, 1937 (33), May 9, 1937 (2), May 16, 1937 (28), May 23, 1937 (14), May 31, 1937 (27), June 6, 1937 (24), June 19, 1937 (84), June 25, 1937 (172), July 11, 1937 (1), July 18, 1937 (1), August 1, 1937 (5), August 7, 1937 (1), August 13, 1937 (5), August 31, 1937 (1).

DIPTERA

Botanobia sp. June 6, 1937 (16), June 13, 1937 (3), June 19, 1937 (26), June 25, 1937 (18).

HYMENOPTERA-FORMICIDAE

Solenopsis xyloni MacCook (ant) Oct. 11, 1936 (4), Oct. 18, 1936 (4), Oct. 25, 1936 (35).

ARACHNIDA

Misumessus rosea Keys (spider) Oct. 4, 1936 (1), Oct. 11, 1936 (1), Oct. 18, 1936 (3), April 26, 1937 (2), May 9, 1937 (2), May 16, 1937 (2), May 23, 1937 (1), May 31, 1937 (2), June 6, 1937 (2), June 19, 1937 (4), June 25, 1937 (26), July 11, 1937 (8), August 1, 1937 (1), August 25, 1937 (2).

Metargiope trifasciata F. (spider) August 7, 1937 (2), August 25, 1937 (4).

Mites of Family Trombidiidae and Erythraeidae Oct. 25, 1936 (1), Nov. 1, 1936 (6), Nov. 14, 1936 (3), Dec. 10, 1936 (3), April 26, 1937 (32), May 2, 1937 (10), May 9, 1937 (3), May 16, 1937 (3), May 23, 1937 (33), May 31, 1937 (16), June 6, 1937 (5), June 25, 1937 (1), August 13, 1937 (2).

SUMMARY

1. It was found to be possible to report quantitative invertebrate collections from a climax, central Oklahoma, prairie obtained by examination of sod and by the sweep net method, in milligrams of weight and in cubic centimeters of total volume.

2. In both herb and ground collections, curves for milligrams and for cubic

centimeters were similar in direction. This study indicated that it would not be necessary to compile both. Volume was favored because it was a stable value, while weight varied due to drying of the collections and was an approximate value.

3. The picture of the annual population cycle made from weights or volumes per collection did not correspond to that formulated on the basis of number of individuals per collection. The greatest discrepancy occurred in the late summer period, when the numbers declined but the weight and volume of the collections remained high. The question was raised: can a valid picture of the annual cycle be obtained solely on the basis of number of individuals per collections, as has been done in similar studies in the past?

4. The term "herbal arthropod influent" was given an objective definition: an arthropod which has a content of one-half cubic centimeter or over in at least one collection or whose total number in one collection is twenty individuals or over. Seventeen arthropod influents fulfilled these requirements and were tabulated as to their seasonal occurrence.

The author wishes gratefully to acknowledge the aid of Mrs. O'Reilly Sandoz; of Morgan Hebard who identified Orthoptera; and W. M. Barrows who identified spiders. The idea used in this paper emerged from a conversation with Dr. V. E. Shelford, University of Illinois, although no responsibility can be attached to him for its actual application.

REFERENCES

BIRD, R. D. 1930—Biotic communities of the aspen parkland of central Canada. Ecology **11**:356-422.

CARPENTER, J. R. 1936—Quantitative community studies of land animals. Jour. An. Ecol. **5**:231-245.

———1939—The Biome. Amer. Midl. Nat. **21**(1):75-89.

DAVIDSON, V. S. 1932—The effect of seasonal variability upon animal species in total populations in a deciduous forest succession. Ecol. Monogr. **2**:305-333.

SHELFORD, V. E. AND SIGURD OLSON. 1935—Sere, climax and influent animals with special reference to the transcontinental coniferous forest of North America. Ecology **16**:375-402.

Herpetological Notes from Indiana

Paul L. Swanson

The following reptiles and amphibians were collected in Indiana from 1934 to 1938 by David C. Swanson and the writer. Most of the species are represented in the collection donated to the Carnegie Museum. Some were kept alive at our exhibit and were never preserved. Dr. M. Graham Netting identified all of the specimens received by the Museum.

Our positions as foresters for the Emergency Conservation Works and the Resettlement Administration gave us an excellent opportunity for collecting. We worked on eight different projects in as many counties. With from 200 to 400 men under our supervision, working in the woods and fields, many of whom brought us specimens, we were fortunate in procuring large numbers of specimens.

Although space does not permit mentioning all of those who brought us specimens, we are particularly indebted to the following: Theodore Davis and Roy Robertson of Nashville, Indiana; A. P. Blair of Indiana University; Wm. B. Barnes, L. C. Pickett, Wm. Seng, H. B. Dickerson, Darrel Martin, and Luther Corbin, all of Martin County; and Randall Stevens of the Jasper-Pulaski Game Reserve.

The aim of these notes is to give an idea of the relative abundance of the different species at the time. Rarely has one the opportunity to have so many interested men in the field bringing in specimens.

Serpentes—Snakes

Carphophis amoena helenae (Kennicott). Worm Snake.—Brown, Martin, Monroe and Jackson Counties. The most common small snake. Some specimens have the internasals and prefrontals separate.

Diadophis punctatus edwardsii (Merrem). Ring-Necked Snake.—Martin, Brown and Morgan Counties. Of the small species, this is second to *Carphophis* in abundance in the counties mentioned. Some individuals had a mid-ventral series of black spots; most did not.

Heterodon contortrix (Linné). Hog-Nosed Snake. — Jasper - Pulaski, Martin, Brown, Pike, Posey, Greene, Daviess, Jackson, Morgan and Monroe Counties. Very common in all areas from which we collected. Melanistic specimens from the north were grayish; from the south, a satiny black. According to present descriptions, all of the many scores we collected were *contortrix*. Northern speecimens, however, are notably smaller and not so brightly marked.

Opheodrys aestivus (Linné). Rough Scaled Green Snake.—Monroe, Jackson, Morgan, Brown, Greene, DuBois, Pike and Martin Counties. Very com-

mon. We often secured as many as eight in one day. We saw one specimen drop from a high limb of a tree to a branch ten feet from the ground.

Coluber constrictor flaviventris (Say). Blue Racer.—Martin, Brown, Pike, Greene, Monroe, DuBois, Daviess and other counties. Dr. Netting identified all of our specimens as *flaviventris*, although all that we obtained from southern Indiana were black in color. Northern Indiana specimens are quite bluish. Very common.

Elaphe obsoleta obsoleta (Say). Pilot Black Snake.—Wabash, Brown, Martin, Gibson, Pike, Monroe, DuBois and other counties. In southwestern Indiana this species is known as the Chicken Snake, and Cow Snake. Those from extreme southwestern counties have pronounced grayish or whitish markings; approachiing the north they become more like the eastern form with reddish brown markings. The anterior part of the ventral surface is usually very white on southwestern individuals.

Elaphe vulpina (Baird and Girard). Fox Snake.—Hay lists specimens from southern Indiana. We have never seen them there, but we have taken a good many from the Jasper-Pulaski Game Reserve in northern Indiana.

Pituophis sayi sayi (Schlegel). Bull Snake.—We have had a number of specimens from the Jasper-Pulaski Game Reserve; none from southern Indiana.

Lampropeltis calligaster (Harlan). Brown King Snake.—Evidently not common. We found a specimen that had been run over by a car, six miles south of Plainville in Daviess County. This is the only one for which we have found any actual record. Myers states that they are "occasional" but does not cite any specific locality. This specimen is no. 9791 in the Carnegie Museum.

Lampropeltis getulus nigra (Yarrow). Black King Snake.—Vanderburg, Martin, DuBois, Pike and Jackson Counties. Rather common in southwestern Indiana. Although we have collected several from Jackson County, we have never seen a specimen from Brown County, which adjoins it on the north, and in which we have collected very extensively.

Lampropeltis triangulum syspila (Cope). Southern Milk Snake.—Martin, Brown, Jasper-Pulaski Counties. Brown County specimens donated to the Carnegie Museum (CM 9742, 9803) were designated as intergrades with *triangulum triangulum*. To the writer they seem more referable to *syspila;* they are more brilliantly colored and the bands extend farther down the sides, giving the appearance when viewed from above of being encircled wtih bands. This also holds true of some of the specimens we collected on the Jasper-Pulaski Game Reserve. Not very common in southern Indiana.

Natrix kirtlandii (Kennicott). Kirtland's Water Snake.—We have taken but one specimen; that from Brown County. Hay states that they were common around Indianapolis. They are evidently rather uncommon farther south.

Natrix sipedon sipedon (Linné). Banded Water Snake.—Common in all

parts of state from which we have collected. The southern Indiana specimens seem to be lighter colored and have fewer bands than the Pennsylvania form with which we are familiar.

Natrix erythrogaster erythrogaster (Forster). Red Bellied Water Snake.—Pike, DuBois, Posey Counties. Fairly common in extreme southwestern Indiana. We failed to procure specimens from Martin and Brown Counties.

Storeria dekayi (Holbrook). DeKay's Snake.—We secured a few specimens from Jasper-Pulaski Game Reserve. They are definitely rare in Martin and Brown Counties, as we failed to secure a single specimen, although this is a species ordinarily easy to collect.

Storeria occipito-maculata (Storer). Red-Bellied Snake.—We have taken this species in both Brown and Martin Counties but it does not seem to be very plentiful.

Virginia valeriae elegans Kennicott. Virginia's Snake.—Two specimens from Brown County. Seemingly rare.

Thamnophis sirtalis sirtalis (Linné). Common Garter Snake.—Brown, Gibson, Martin and Monroe Counties. This species is not abundant in southern Indiana. We took barely a dozen specimens.

Thamnophis sauritus sauritus (Linné). Ribbon Snake.—Pike, Jasper-Pulaski Counties. Not very plentiful in southern Indiana, probably because habitat is unfavorable in most counties.

Agkistrodon mokasen Beauvois. Copperhead.—Morgan, Monroe, Martin, DuBois and Brown Counties. The most common poisonous snake in Indiana. We frequently secured three and four per day in Brown County. They attain a larger average size than eastern specimens; individuals three feet in length and over are not uncommon.

Sistrurus catenatus catenatus (Rafinesque). Massasauga.—Not likely to be found in the southern half of the state. We obtained several from Jasper-Pulaski Counties, and heard of others being killed in neighboring counties.

Crotalus horridus horridus (Linné). Timber Rattlesnake.—Martin, Brown, Jackson, Morgan and Monroe Counties. Still quite common in the wooded sections of southern Indiana. In Martin County about 15 to 20 are killed annually according to reliable reports. One crew of 25 men working for the Resettlement Administration in Brown County killed 17 rattlers and 41 copperheads in one summer, practically all in Jackson township. This was vouched for both by the foreman and the superintendent. They are also common on the Morgan-Monroe State Forest. The personnel of the CCC Camp there informed us that Timber Rattlers were never found north of Indian Creek on the north edge of the forest. That perhaps marks the northern limits of their range in Indiana. Many specimens well over four feet in length were taken.

There are a number of snakes recorded or reported from southern Indiana which we failed to procure, in spite of standing offers of making it worthwhile for any man who brought us unusual specimens. Among them are *Farancia abacura, Heterodon simus, Elaphe guttata, Lampropeltis getulus getulus, Potamophis striatulatus, Tropidoclonion lineatum, Thamnophis butler, Agkistrodon piscivorus* and others. We encouraged bringing in all small snakes. We made several trips into Posey County in fruitless efforts to find *Agkistrodon piscivorus*. The natives of the vicinity were not familiar with any snake which answered the description of the moccasin. The first authentic record for this species still remains to be taken.

CAUDATA—SALAMANDERS

Triturus viridescens louisianensis (Wolterstorff). Newt.—A few specimens from the vicinity of Shoals, Martin County.

Ambystoma opacum (Gravenhorst). Marbled Salamander.—Pike and Brown Counties. Found in excavating work.

Ambystoma texanum (Matthes). Small Mouthed Salamander.—Jasper-Pulaski, Daviess, Martin, Pike and Gibson Counties. This was the most commonly found salamander in ponds during the breeding season in the counties mentioned.

The CCC boys on the Pike County forest found quite a number of small *texanum* when digging. They called them "mud eels." These were still in hibernation while we were catching adults in the ponds. We surmised that they were possibly one year old and that they do not breed until the second year.

Ambystoma tigrinum tigrinum (Green). Tiger Salamander.—Although we frequently hunted for this species, we took them only once; in Gibson County.

Plethodon cinereus (Green). Red-Backed Salamander.—This is a fairly common species in favorable habitat in southern Indiana. Martin and Brown Counties.

Plethodon dorsalis (Cope). Red-Backed Salamander.—Martin and Brown Counties. On April 8, 1938, SW1/2-Section 17-9-2 in Brown County I captured 8 *cinereus* and 6 *dorsalis*, some of them practically side by side.

Plethodon glutinosus (Green). Slimy Salamander.—Jasper-Pulaski and Brown Counties.

Eurycea bislineata bislineata (Green). Two-Lined Salamander.—Martin and Brown Counties.

Eurycea longicauda longicauda (Green). Long Tailed Salamander.—Brown County. Fairly common.

Eurycea lucifuga Rafinesque. Cave Salamander.—Under stones between the Twin Caves, Lawrence County.

SALIENTIA—FROGS AND TOADS

Scaphiopus holbrookii holbrookii (Harlan). Spadefoot Toad.—On May 3, 1937 four miles west of Shoals along the White River bottom we collected about twenty spadefoot toads. This was the only time and place that we observed this species.

Bufo americanus americanus Holbrook. American Toad.—Posey and Brown Counties. This species is not very common in southern Indiana.

Bufo woodhousii fowleri Garman. Fowler's Toad.—Pike, Daviess, Martin, Posey and Brown Counties. On April 28, 1936, a warm rainy night, midway between Washington and Montgomery we stopped at a small pond to collect toads. They were crossing the paved road and all over the field towards the pond. One had to step carefully to avoid trampling them. Conservatively 1000 were in and around the pond which was about 100 x 200 feet. On June 16, 1937, I caught 80 *fowleri* in thirty minutes in Brown County. On April 13, 1938 I caught 100 in an hour, also in Brown County. Adults and young are commonly seen in the forests during early summer.

Acris crepitans (Baird). Cricket Frog.—Jasper-Pulaski, Daviess, Martin, Warrick, Pike, Posey and Brown Counties. Breeding calls are most commonly heard much later than *Hyla crucifer* and *Pseudacris*. About the same time *Hyla versicolor versicolor* and *Bufo. woodhousii fowleri* are calling.

Pseudacris nigrita triseriata (Wied). Swamp Tree Frog.—Daviess, Pike, Martin, Gibson, Lawrence, Warrick, Monroe and Posey Counties. This is by far the most common frog evident in the spring in southern Indiana. It is about the earliest to be heard. In one small marshy area of about 75 square feet near Shoals, I counted 35 specimens; there were probably many more. When close to such a chorus the noise is almost deafening.

Hyla crucifer Wied. Spring Peeper.—Pike, Monroe, Martin, Lawrence and Brown Counties. While not rare, this frog is not very common in southern Indiana compared with other species. Specimens caught near Shoals, at a place locally known as the "Gourd Neck" were a dark chocolate brown with the "X" just barely discernible. All other specimens were of normal coloration.

Hyla versicolor versicolor (Le Conte). Big Tree Frog.—Pike, Martin, Posey and Brown Counties.

Rana areolata Baird and Girard. Hoosier Frog.—Pike, Vanderburg, Martin, DuBois and Warrick Counties. Breeds in March and April in southern Indiana. This loud distinctive call can easily be heard for ¾ mile. I have frequently heard them from within the city limits of Loogootee and Odon. They are quite plentiful in the counties mentioned, but I failed to secure any from Brown County although I hunted there often. They are quite difficult to catch as they cease calling and dive when approached.

Rana catesbeiana Shaw. Bull Frog.—Pike, Warrick and Brown Counties.

In the extreme southern counties, I found hundreds of dead ones in the spring of 1936. They possibly did not hibernate deeply enough to escape the severe winter. In Brown County I frequently found them in small puddles on top of the highest hills; always immature specimens however.

Rana clamitans Latreille. Green Frog.—Jasper-Pulaski and Brown Counties. Seemingly not very numerous in southern Indiana.

Rana pipens Schreber. Leopard Frog.—Watrick, Pike, Gibson, Martin, DuBois, Lawrence, Posey, Henry, Monroe and Jasper-Pulaski Counties. Most of these specimens looked more like *Rana sphenocephala* to me, although they were identified as *pipiens* by the Carnegie Museum.

Rana sylvatica Le Conte. Wood Frog.—Monroe County.

Sauria—Lizards

Sceloporus undulatus undulatus (Latreille). Swift.—Brown, Pike, Martin, Morgan, Monroe, and Jackson Counties. Very common in southern Indiana. We would often get eight or ten in a day without hunting for them. In May the females seemed to outnumber the males about two to one.

Ophisauris ventralis (Linné). Glass "Snake."—Fairly common on the Jasper-Pulaski Game Reserve. I failed to procure any from southern Indiana.

Cnemidophorous sexlineatus sexlineatus (Linné). Sand Lizard.—Quite common on the Jasper-Pulaski Game Reserve. I never saw one in southern Indiana. Perhaps the habitat of the sections from which we collected was unfavorable for this and the preceding species, as they are both southern forms.

Eumeces fasciatus (Linné). Skink.—Pike, Posey and Brown Counties. Fairly common in southern Indiana. We secured specimens of many color phases and sizes, including a huge eleven inch specimen from Brown County.

Eumeces laticeps (Schneider). Skink.—Martin County.

Testudinata—Turtles

Sternotherus odoratus (Latreille). Stink Pot.—Several specimens from the Jasper-Pulaski Game Reserve.

Kinosternon subrubrum subrubrum (Lacépède). Mud Turtle.—Jasper-Pulaski and DuBois Counties.

Macrochelys temminckii (Troost). Alligator Snapper.—On one of our trips to Posey County a specimen had been caught a few hours before we arrived at Hovey's Lake. It had been cleaned, evidently to be eaten, but I secured the carapace. It was about the size of a large *Chelydra serpentina* and had the prominent keels typical of *temminckii*. We were told that large

specimens, which answered the description of *temminckii,* were frequently taken from the lake.

Chelydra serpentina (Linné). Snapping Turtle.—Jasper-Pulaski, Daviess, Brown and Martin Counties. This turtle is probably quite common all over the state, but we made no effort to collect any kind of turtles.

Clemmys guttata (Schneider). Spotted Turtle.—We caught a number of specimens in the Jasper-Pulaski Game Reserve.

Emys blandingii (Holbrook). Blanding's Turtle.—This species is very common in Jasper-Pulaski and vicinity. There it is about the most easily caught species in quantities.

Terrapene carolina (Linné). Common Box Turtle.—Brown, Martin, Pike, Jasper-Pulaski Counties. The most common species in southern Indiana. On hot summer days they may be found partially submerged in mud around springs and puddles. David Swanson counted 12 in one puddle. I counted 8 around one small spring.

Terrapene ornata (Agassiz). Western Box Turtle.—We took a great many specimens from the Jasper-Pulaski Game Reserve, but only one *carolina.*

Chrysemys bellii marginata (Agassiz). Painted Turtle.—Jasper-Pulaski, Martin, Pike and Brown Counties.

Pseudemys scripta troostii Holbrook. Terrapin.—One infant specimen was found on the road beside two DOR's;* another infant and an adult; in Posey County near Hovey's Lake. It was identified by the Carnegie Museum as belonging to this species.

Pseudemys elegans (Wied). Cumberland Terrapin.—The caretaker at Hovey's Lake, Posey County, had about a dozen specimens which had been taken by hook and line. I obtained two of the adults from him; they had the yellow lines and distinct red bands on the sides of the head typical of *elegans.* Along the high water line of the recent flood, on May 24, 1936 at Half Moon Pond, I observed over 40 dead specimens in three-quarters of a mile. Possibly they did not hibernate deeply enough to escape freezing from the severe winter. As they were advancing in decay I did not take any of them.

Unfortunately the large container in which I had most of my preserved turtles, including an *elegans* and the *temminckii* carapace and several others, was left at my Martin County location. When it was finally shipped to the Carnegie Museum, it was empty.

Amyda spinifera (Le Sueur). Soft Shelled Turtle.—Several specimens from Jasper-Pulaski Game Reserve.

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* Dead on road.

REFERENCES

ALLYN, WILLIAM P. 1934—Representative Animal Life in Indiana. The Teachers College Journal **6**(2):95-125.

ATKINSON, CURTIS. 1896—Batrachia of Turkey Lake. Proc. Ind. Acad. Sci. **1895**: 258-261.

BLANCHARD, F. N. 1925—A Collection of Amphibians and Reptiles from Southern Indiana and Adjacent Kentucky. Pap. Mich. Acad. Sci. **5**:367-388, pl. 22, 23.

BLATCHLEY, W. S. 1891—Notes on the Batrachians and Reptiles of Vigo County Indiana. Journal Cincinnati Soc. Nat. Hist.: 22-35.

EIGENMANN, G. H. 1896—Testudinata of Turkey Lake. Proc. Ind. Acad. Sci. **1895**: 262-264.

GRANT, CHAPMAN. 1935—Herpetological Notes from Northern Indiana. Proc. Ind. Acad. Sci. **45**:323-333.

GRAVE, B. H. 1930—Amphibia of Montgomery County Indiana. Proc. Ind. Acad. Sci. **40**:339.

HAHN, WALTER H. 1908—Notes on the Mammals and Cold Blooded Vertebrates of the Indiana University Farm. Proc. U. S. Nat. Mus. **35**:545-581.

HAY, OLIVER P. 1891—Batrachians and Reptiles of Indiana. Report of State Geologist **17**:409-610.

LYON, MARCUS W., JR., AND CHARLES ALLEN BISHOP. 1935—Bite of the Prairie Rattlesnake *Sistrurus catenatus* RAF. Proc. Ind. Acad. Sci. **45**:253-256.

MYERS, GEORGE S. 1925—A Synopsis for the Identification of the Amphibians and Reptiles of Indiana. Proc. Ind. Acad. Sci. **34**:277-294.

———1926—Notes on Indiana Amphibians and Reptiles. Proc. Ind. Acad. Sci. **36**:337-340.

ORTENBURGER, A. I. 1921—A List of Amphibia and Reptiles Collected in Indiana. Copeia no. 99: 73-76.

PIATT, JEAN. 1930—Herpetological Report of Morgan County, Indiana (Excepting Turtles). Proc. Ind. Acad. Sci. **40**:361-368.

REDDICK, G. 1895—The Snakes of Turkey Lake. Proc. Ind. Acad. Sci. 261-262.

REYNOLDS, A. E. AND E. G. BLACK. 1935—The Salamanders of Putnam County. Proc. Ind. Acad. Sci. **45**:287-294.

STEJNEGER, LEONHARD AND THOMAS BARBOUR. 1933—A Check List of North American Amphibians and Reptiles. Third Edition. Harvard University Press.

SWANSON, PAUL L. 1938—Pituophis and Scaphiopus in Indiana. Amer. Midl. Nat. **20**(3):713.

POLK, PA.

F------ The "Flats."
K—·—·— The "knob" area.
L——— The lake area.
P·-·-·- The prairie area.
L.W.V.------ The lower Wabash Valley

Map of Indiana

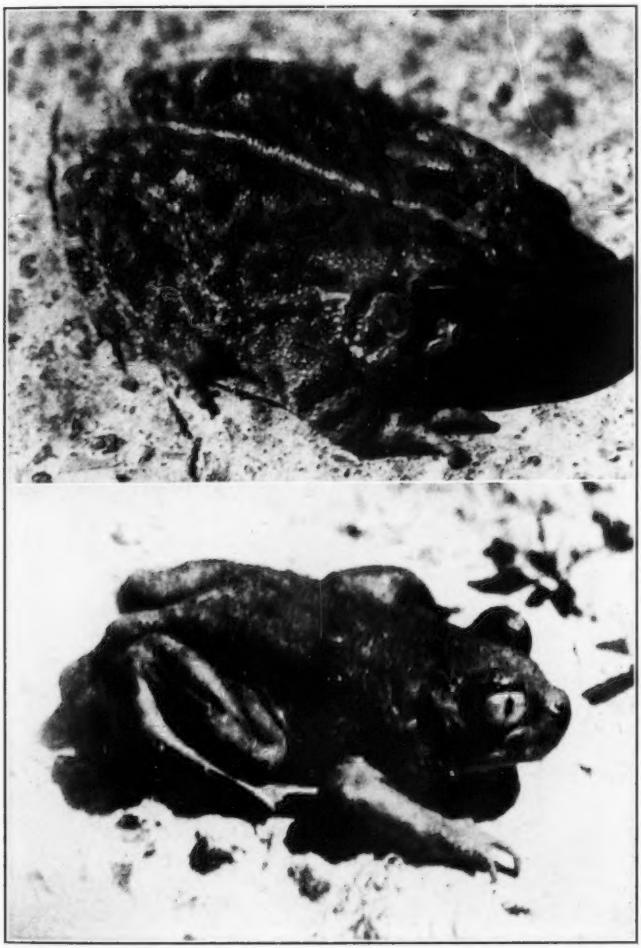

PLATE 1: Top, *Bufo woodhousii fowleri* Garman from Brown County; Bottom, *Scaphiopus holbrookii holbrookii* (Harlan) from Martin County.

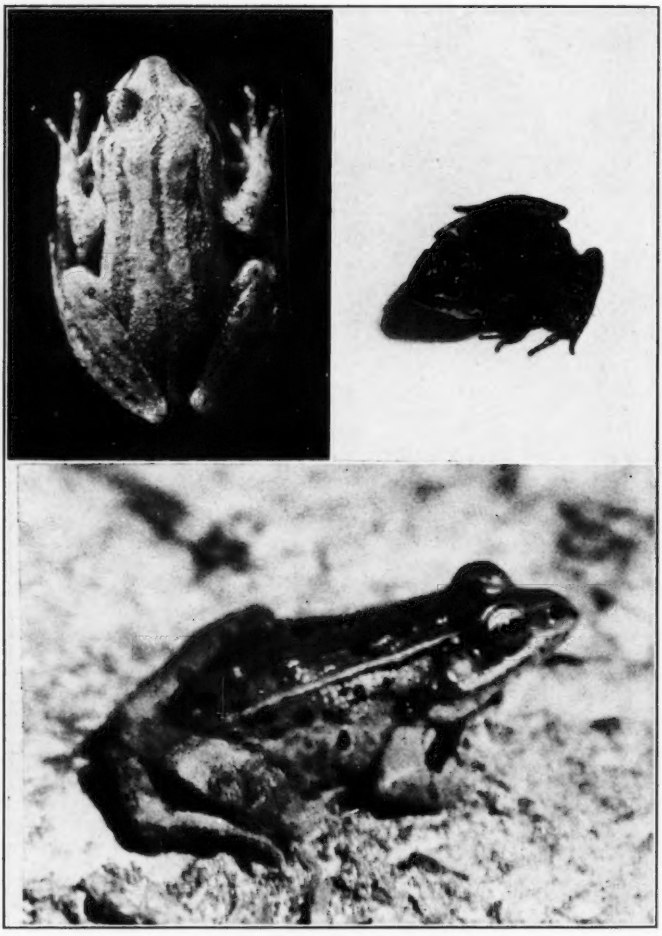

PLATE 2: Top left, *Pseudacris nigrita triseriata* (Wied), about x2½, Martin County; Top right, *Rana areolata* Baird and Girard, from Martin County; Bottom, *Rana pipiens* Schreber, from Brown County.

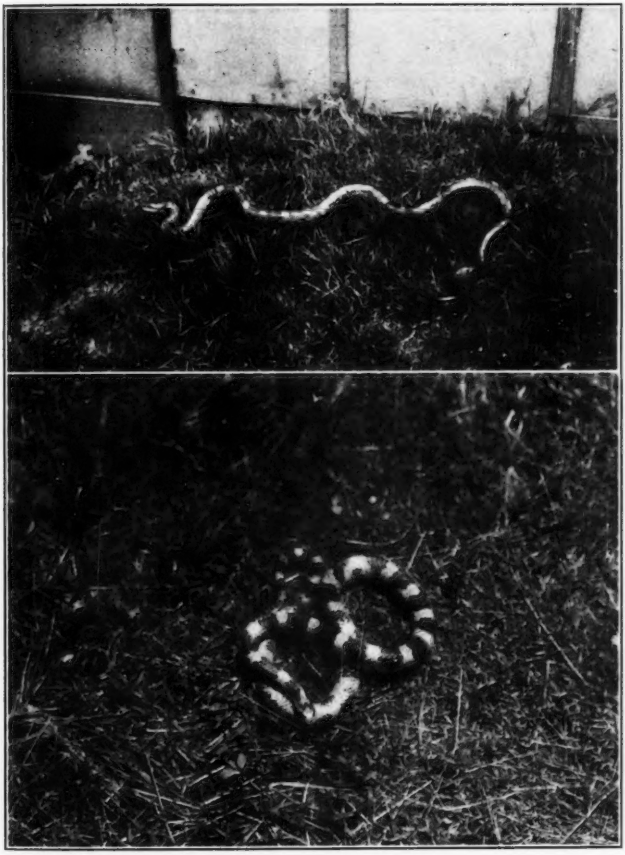

PLATE 3: Top, *Elaphe obsoleta obsoleta* (Say), from Pike County; Bottom, *Lampropeltis triangulum syspila* (Cope), from Brown County.

A New Plethodontid from Eastern Oklahoma*

George A. Moore and R. Chester Hughes

On April 8, 1939, six specimens (presumedly adult) of an apparently new neotenic plethodontid salamander were discovered in Tyner Creek near Proctor, Oklahoma. The first specimens were discovered accidentally, during a search for ammocoetes, under cold swift-running water several inches deep, just above the bridge on Highway U. S. 62 one-half mile east of town. By loosening the deep coarse sand and gravel of the creek bed, the salamanders were routed and then caught downstream in a 4-foot "common sense" seine. These specimens were all fixed in 10 percent formalin. On April 29 thirteen more "adults" were obtained at the same place—12 of these were kept alive in the laboratory. A thorough search along the banks of the creek failed to yield adults of any salamander on these first two trips.

On May 29 the search began in Marvin's Spring about 6 miles upstream from the bridge above-mentioned. The water of this large spring issues from beneath a steep bank and flows over a gravelly bed. By means of a 16-mesh wire sieve and a 4-tined rake we obtained 6 larvae and 1 adult of the new form and 15 larvae of *Eurycea melanopleura* (Cope 1894) Stejneger and Barbour 1917. Under logs and rocks near the water's edge and in the water we found 15 adults of the latter species. We found larvae of either species and adults of *E. melanopleura* only in the immediate vicinity of the spring, and, although we examined several seemingly favorable locations, no more adult specimens of the new species were discovered until we were about 1 mile above the bridge. Here we secured 4 adults; 17 more were taken near the bridge. A concentration of specimens near the bridge seems to be due to the fact that the stream bed here contained loose coarse gravel to a depth of several inches, affording excellent hiding places for the secretive animals.

The new form is provisionally assigned to the genus *Eurycea* Rafinesque 1882 although certain larval conditions, such as the primitive arrangement of the teeth, the form of the tongue, and the absence of nasolabial grooves and certain skull bones, preclude a positive generic determination. Except for these larval features it conforms to the diagnosis (Dunn 1926) of that genus. Moreover it closely resembles the paedogenetic *Eurycea neotenes* Bishop and Wright 1937.

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* A contribution from the Zoological Laboratory, Oklahoma Agricultural and Mechanical College.

The writers are indebted to Dr. S. C. Bishop, University of Rochester (New York, and Dr. E. R. Dunn, Haverford College (Pennsylvania), for helpful suggestions; to Dr. Leo T. Murray, Baylor University (Texas), for having lent us his entire series (13 larval specimens) of *E. neotenes;* and to Drs. John D. Mizelle and Ragnar Nathanael Danielson of Oklahoma Agricultural and Mechanical College for generous assistance with the collecting.

Dissections of several females indicated sexual maturity—they had enlarged ovaries with plainly visible eggs. In the most mature example one ovary had 7, the other 5, large ova one of which measured 1.8 x 1.5 mm. This specimen, captured on May 29, was killed on June 20. It should be acknowledged that on a specimen kept in a moist chamber the gills and caudal fin suffered marked diminution in size, — otherwise there was little evidence of metamorphosis.

The name *Eurycea tynerensis* is proposed for the new form. The description which follows is based on a study of 41 "adult" specimens of which 30 remain intact and are herewith designated as cotypes.

Eurycea tynerensis sp. nov.
Figs. 1 and 2

Description.—A small neotenic species. Sexes not appreciably different in size or appearance. Measurements in millimeters taken from 13 specimens. Total length, 51.5 (44-61). Length of body from tip of snout to posterior end of anus, 27.5 (20-33). Length of tail, 22.4 (16-28). Length of head from tip of snout to dorsal end of hindmost pharyngeal cleft, 6.7 (5.5-7.5). Length ratios: tail in total, 2.3; head in total, 7.7; head in body, 4.1. Greatest width of head in head length, 1.8. Maximum depth of head in head length 2.8. Diameter of eye about equal to width of interorbital space.

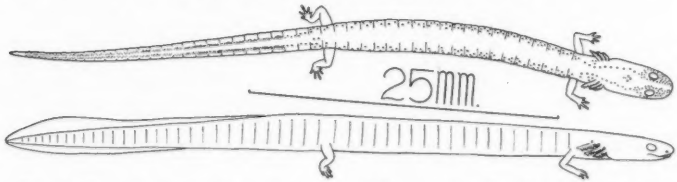

Fig. 1. *Eurycea tynerensis* sp. nov., an adult specimen, dorsal and lateral views, free-hand studies. The stipples in the dorsal view comprise an approximately accurate representation of the number and arrangement of individual lateral line organs visible from above.

Head depressed, widest just in front of gills; snout broadly truncate; no eyelids; no nasolabial grooves; gills with long rami and numerous filaments; costal grooves 19.6 (19-20); costal grooves between appressed toes 9.5 (8-11); trunk and anterior fourth of tail subcylindrical—remainder of tail somewhat compressed, especially toward the tip; caudal fin wider dorsally, shorter on ventral side, and on dorsal side from one-half to two-thirds of length of tail. Median longitudinal columns of yellow oil-bearing tissue, externally visible, occur beneath the skin, in the middorsal and midventral areas of the tail. Digits 4-5, free; in order of length—fingers 3, 2, 4, 1 and toes 3, 4, 2, 5, 1; phalangeal formulae—fingers 1, 2, 3, 2 and toes 1, 2, 3, 3, 2.

General color of dorsal surface consists of approximately equal amounts of black and cream, finely intermingled in the form of irregular spots and streaks, with a tendency in some individuals for the cream to be concentrated into as many as three pairs of longitudinal rows of spots (larval areas). Color pattern

varies widely from specimens having distinct larval areas or back distinctly lighter than sides to individuals with melanophores so numerous that they have invaded the larval areas to give an almost solid black appearance. Underparts of trunk and head immaculate except for a few melanophores on chin and margin of lower jaw. Dorsal surface of tail bears a broad light brown band which tapers gradually posteriad.

Fig. 2. Where the first specimens of *Eurycea tynerensis* sp. nov. were collected. A view of Tyner Creek looking north from the bridge on Highway U. S. 62 one-half mile east of Proctor, Adair County, Oklahoma. Photograph taken April 29, 1939, by Dr. Ragnar Nathanael Danielson, Oklahoma Agricultural and Mechanical College.

Lateral line organs—very numerous, increasing with age, over 400 pairs in an adult; variable in size, 68-146 μ in maximum diameter; variable in shape, ellipsoidal to spheroidal; variable in arrangement but mostly lateral in distribution; abundant on sides of face, especially before and behind eyes with a few above and beneath eyes; a few under mandibles; those of trunk widely and irregularly scattered between costal grooves; those of tail especially numerous, smaller, and crowded in a pair of narrow dorsosubmedian bands, a sizable cluster behind insertion of each hind limb.

Larvae.—Larvae not very different in appearance from adults except in the proportionately greater size of gills and caudal fin and in the smaller number of lateral line organs. Measurements in millimeters taken from 6 specimens—total length 23.5 (17.5-31), length of tail 8.3 (5-11.5). Costal grooves 19.3 (19-20).

Behavior.—Laboratory specimens kept in shallow water frequently lie with their heads protruding from beneath stones. They usually withdraw completely from view upon the slightest disturbance. They are apparently nocturnal, prowling at night, for they are often seen scurrying into seclusion when lights are turned on. When ample cover is provided they almost invariably hide during the day.

Type locality.—Tyner Creek, a tributary of Barron Fork Creek, near Proctor, Adair County, Oklahoma.

Habitat.—Interstices between stones and pebbles in coarse loose sand under cold swift shallow water of springs and small streams.

Museum specimens.—Thirty cotype specimens, located, 12 in the United States National Museum and 6 each in the zoological museums of the University of Michigan, the University of Oklahoma, and the Oklahoma Agricultural and Mechanical College.

Discussion

Eurycea tynerensis is closely similar to *Eurycea neotenes,* the only previously described neotenic species of the genus, but differs from it in having (1) a broader more truncate snout, (2) a larger number of costal grooves, (3) a smaller size, and (4) a somewhat darker coloration. For comparative study on *E. neotenes* we had at our disposal, besides the original description (Bishop and Wright 1937), a number of larvae (see footnote, title page).

The new species differs from *Eurycea multiplicata* (Cope 1869) Stejneger and Barbour 1917, the only other known member of the genus having such a large number of costal grooves, in being neotenic—our specimens differ from the larva of that species as described by Dunn (1926) in that the coloration of the back is, but rarely in the adults and never in the larvae, noticeably lighter than the sides.

REFERENCES

Bishop, S. C. and M. W. Wright. 1937—A new neotenic salamander from Texas. Proc. Biol. Soc. Wash. **50**:141-143.

Dunn, E. R. 1926—The salamanders of the family Plethodontidae. 441 p. Northampton, Massachusetts.

Food of Central Wisconsin Horned Owls

Frances Hamerstrom and Oswald Mattson

The area[1] from which pellets were gathered is a sandy region of jack pine *(Pinus Banksiana)* and scrub oak (*Quercus* spp.) islands interspersed with grass and willow (*Salix* spp.) marshes and large aspen *(Populus tremuloides)* flats. Agriculture, which followed lumbering, drainage and fire, has been largely abandoned and most of the area is ungrazed and brushy.

In 1935-36 and 1936-37, 687 horned owl *(Bubo virginianus)* pellets or substantial fractions thereof were gathered, 116 for the first winter and 571 from the second. A few autumn or spring pellets picked up are also included. Table1 shows the minimum number of individual prey in each lot, except in the case of snakes and some insects which we were unable to count.

TABLE 1.—ANALYSIS OF 678 PELLETS

Common name	Scientific name	116 pellets 1935–1936	571 pellets 1936–1937
Fish	Pisces		1
Frog	Rana pipiens	4	47
Snake	Ophidia	In 2 pellets	In 4 pellets
Grebe	Colymbus sp.		1
Mallard	Anas platyrhynchos	(1)*	(1)
Ruffed grouse	Bonasa umbellus		3(2)
Pinnated grouse	Tympanuchus cupido americanus		7(5)
Sharptailed grouse	Pediocetes phasianellus campestris		4(1)
Bob-white quail	Colinus v. virginianus		1
Rail	Rallinae		1
Coot	Fulica americana	1	
Wilson snipe	Capella delicata		1
Solitary sandpiper	Tringa solitaria		1
Unidentified shorebirds	Charadriiformes		3
Screech owl	Otis asio		1
Horned owl	Bubo virginianus		(1)
Unidentified owl	Strigiformes		1
Woodpecker	Picinae		2
Crow	Corvus brachyrhynchos		2(1)
Robin	Turdus migratorius		(2)
Unidentified passerine birds	Passeriformes		16
Unidentified birds		2	15
Mole	Scalopus aquaticus		1
Long-tailed shrew	Sorex cinereus		21
Short-tailed shrew	Blarina brevicauda	1	10
Weasel	Mustela sp.		3
Mink	Mustela vison		(1)
Skunk	Mephitis mephitis		2(1)

1 Project LD-WI-5, Farm Security Administration, Region II, Mr. W. T. Cox, Regional Forester-Biologist.

Cottontail	Sylvilagus floridanus	24(1)	96
Striped ground squirrel	Citellus tridecemlineatus		2
Red squirrel	Sciurus hudsonius		1
Gray squirrel	Sciurus carolinensis		4(2)
Fox squirrel	Sciurus niger rufiventer		2(1)
Flying squirrel	Glaucomys sp.		1
Deer mouse	Peromyscus sp.	29(11)	146
Meadow mouse	Microtus sp.	14	879
Lemming mouse	Synaptomys cooperi	4(1)	4
Red-backed mouse	Clethrionomys gapperi		3
Unidentified mice		9	46
Muskrat	Ondatra zibethica	2	12(1)
Rat	Rattus norvegicus		2 adults 5 young
Jumping mouse	Zapus hudsonius		4(2)
Unidentified mammals other than mice			2
Crayfish	Cambarus sp.	1	2
Grasshopper	Orthoptera	1	3
Unidentified beetle	Coleoptera	1	5
Predaceous diving beetle	Dytiscus sp.		13(1)
Beetle	Calligrapha multipunctata		1
Giant water bug	Belostoma sp.		4
Unidentified insects			In 3 pellets

* The figures in parenthesis indicate the questionable identifications included, i.e., 24(1) means "remains of 23 cottontails plus remains of 1 animal which was probably cottontail."

TABLE 2.—SOME PREY SPECIES OF PARTICULAR INTEREST

Common name	Actual no. of prey in 116 pellets, 1935-1936	Actual no. of prey in 571 pellets, 1936-1937	Prey per 100 pellets 1935-1936	Prey per 100 pellets 1936-1937
Cottontail	24(1)*	96	20.69	16.81
Meadow mouse	15	879	12.93	153.94
Deer mouse	29(11)	146	25	25.57
Unidentified mice	9	46	7.76	8.06
Ruffed grouse	0	3(2)	0	.53
Pinnated grouse	0	7(5)	0	1.23
Sharptailed grouse	0	4(1)	0	.70

* The figures in parenthesis indicate the questionable identifications included, i.e., 24(1) means "remains of 23 cottontails plus remains of 1 animal which was probably cottontail."

Table 2 deals with some prey species of particular interest, most of which are cyclic, and compares the two years on the basis of prey per hundred pellets. During these years several of the prey species were apparently near the low of the cycle.

Pinnated, sharptailed and ruffed grouse populations were low in the first winter and of these sharptails seemed to be most noticeably starting the upswing of the cycle in 1936-37, at which time Hamerstrom[2] estimated the combined pinnate and sharptail population at one bird to 85-100 acres, with a ratio of three sharptails to one pinnate. No grouse remains were found in any pellets of the first winter but several occurred in the 1936-37 pellets.

Meadow mice were markedly less abundant in the second winter than in the first; this was very evident from the number of runways exposed after the snow melted. A total of 466 trap nights in the autumn of 1936 and the early spring of 1937 caught only 2 meadow mice and 18 deer mice. However, there were *more* mice in the pellets of the second winter.

Cottontails were scarce the first winter, but appeared to be even scarcer during the second. Unfortunately we made no cottontail field counts the first year, but in the autumn of the second only 20 were seen in 100 hours in the field.

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2 Hamerstrom, F. N. Jr. A study of Wisconsin prairie chicken and sharptailed grouse. Wilson Bulletin **51**(2):105-120, June, 1939.

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Variability and Environmental Responses of the Kangaroo Rat, Dipodomys heermanni saxatilis*

Frederick H. Dale

Introduction

When Grinnell and Linsdale (1929) reported finding a race of kangaroo rat, *Dipodomys heermanni saxatilis* inhabiting the lava-strewn plains along the eastern edge of the Sacramento Valley, it was apparent that this form would merit special study because the habitat was unique for kangaroo rats and because the geographically intermediate position of this race, *saxatilis*, between the "four-toed" *D. h. californicus* and the "five-toed" *D. h. heermanni* gave promise of yielding more conclusive data on the degree of relationship between these two forms, considered by Grinnell (1922) as conspecific. The problem gave promise also of yielding knowledge of the critical factors influencing distribution, the environmental responses of the animal, the correlation between environment and morphological characters, and on the nature of subspecific characters.

The distribution of a race of this kind is of especial significance in relation to the genus as a whole. *Dipodomys* is known to be restricted to areas of rather specialized nature. When a race is found in an area presenting an unusual modification of this habitat, opportunity is offered for a more critical examination of the requirements of the genus. If the habits of the new race do not differ markedly from those of the other members of the genus it is probable that its environmental requirements are not fundamentally unique, and that comparison with the more nearly typical habitat will disclose features common to both. These features are obviously more likely to be fundamental, as regards the genus as a whole, than those more striking features in which the habitats differ, although the latter may be important in limiting the ranges of geographic races.

It is not always possible to be sure that correlations found between the factors of the habitat and characteristics of the animal living in it imply a real relationship between them. By considering the characters and habits of animals in an unusual habitat, it is nevertheless, possible to suggest relationships that may be sustained in further investigations. It is significant, at least, to learn whether an animal in such a habitat is set off from surrounding subspecies by sharply-marked features, comparable in distinctness to the unusual nature of the environment.

Finally, a subspecies which is geographically intermediate between two forms that differ in characters once considered as being of sufficient import-

* Contribution from the University of California Museum of Vertebrate Zoology.

ance to merit generic separation offers promise of giving clues to the nature of subspecific characters. It is important to know whether the intervening race represents an intermediate condition or not, and whether its characters vary in such manner as to suggest a cline. It is even more important to subject to careful consideration the evidence for the close relation between two kinds of animals differing in characters of seeming generic value, because their arrangement as subspecies of the same species indicates that there is no real difference between subspecific characters and those of the higher categories.

Scope of Study

Investigation of the problem now reported on was begun in the spring of 1934, when specimens then in the Museum of Vertebrate Zoology were examined and compared wtih those of adjoining races. In June of that year field work was begun near the type locality, "mesa near Dale's, on north side of Paines Creek, 700 feet altitude, Tehama County, California."

After 27 days in the field, the work was interrupted, and was not resumed until the spring of 1936. From then until the present (June, 1939) it has been carried on with minor interruptions.

The chief purposes of the field work were the collection of specimens and the analysis of the habitat in which these animals live. Trapping was done to the extent of 4,349 trap-nights; 324 specimens were obtained. Of these, 238 were prepared as skins with skeletons, and the remainder as skins with skulls. All specimens used in the study are now in the Museum of Vertebrate Zoology, to which museum the catalog numbers here used refer.

Trapping was done at five general localities, all in Tehama County, California, east of the Sacramento River: (1) Abraham Plains, 8 miles east of Red Bluff, (2) Dale's, on the south side of Paines Creek, (3) near Dale's on the north side of Paines Creek, (4) near Longs, 1 mile south of the junction of the north and south forks of Battle Creek, and (5) Inskip Forebay, 6 miles southwest Manton. The first two localities are less than ten miles apart, and with no intervening barrier. Specimens from these places were considered together, after preliminary study to be sure they did not differ significantly.

Acknowledgements

The collection of specimens and their study later in the investigation was aided by the facilities of the Museum of Vertebrate Zoology. Acknowledgement is here made for this assistance and that (typing of manuscript) rendered by the personnel of the Works Progress Administration, Official Project No. 465-03-3-192.

Special thanks are due to the late Professor Joseph Grinnell, under whose direction the investigation was initiated, and who furnished much of the inspiration for the field work, to Dr. J. M. Linsdale for many helpful criticisms and suggestions of problems for attack at the outset of the study, and to Professor E. Raymond Hall, who has supervised the greater part of the study carried on at the Museum of Vertebrate Zoology, and who gave critical assistance in preparation of the final report.

The Genus Dipodomys

Phylogenetic Relationships

The kangaroo rats, genus *Dipodomys,* and four other genera, *Perognathus, Microdipodops, Heteromys,* and *Liomys,* are usually classified as comprising the family Heteromyidae, which is limited to the New World.

The kangaroo rats were formerly split into two genera, *Dipodomys,* in which the hallux was absent, and *Perodipus,* in which this digit was present. It was Grinnell (1922) who first recognized that this was an artificial means of classifying these forms. He found the group to be remarkably uniform, and noted that the number of toes on the hind foot was an inconstant feature, differing in forms that are obviously of close relationship. He therefore placed all kangaroo rats in the one genus, *Dipodomys.*

Range and Habitat

Dipodomys occurs most abundantly in the arid southwestern United States and northern Mexico. One widespread species, *D. ordii,* ranges as far north as southern Washington and Montana and eastward to the Mississippi River. No kangaroo rats are known to occur east of the Mississippi.

Within its range, *Dipodomys* is further restricted to arid or semi-arid habitats. As has been mentioned by Grinnell *(op. cit.)* and Howell (1932), the immediate habitat is always arid, although a few races have penetrated into humid coastal areas.

Grinnell believed this restriction to be caused in part by the need for loosely-packed soil, such as is generally associated with arid regions. Howell does not mention this correlation, but says that kangaroo rats, "in the main," are not to be found in areas where the ground is covered by large rocks. He also mentions that they are not "partial to hard ground."

Another factor ordinarily associated with the habitat of *Dipodomys* is sparseness of vegetation. *D. venustus* is said to be an exception to this general rule, and to occur in quite dense chaparral. Probably there are open places in this chaparral, however, where most of the activities of the kangaroo rats occur.

Range of Dipodomys h. saxatilis

Dipodomys heermanni saxatilis occurs in the rocky foothills of northern California, from near Battle Creek, Tehama County, along the eastern side of the Sacramento Valley to near the middle fork of the American River, Eldorado County. It appears to be entirely absent from the cultivated lands along the valley floor, and is most abundant near the crest of the first rise to east. It is believed to be restricted to a strip of some twenty-five miles in width, and about one hundred and twenty miles in length.

Zonally, the range of the subspecies is almost, if not entirely, restricted to Upper Sonoran areas. It may approach the lower limits of the Transition Life-zone, but it has not been taken there. Specimens from near Lyonsville, Tehama County, in the Transition Life-zone, are not typical *saxatilis,* as

compared with specimens from the type locality, and were referred to *D. h. californicus* by Grinnell, Dixon and Linsdale (1930). The alluvial soil of the valley floor occupies most, if not all, of the Lower Sonoran Life-zone adjacent to the range of this form. Possibly the more luxuriant plant growth associated with the presence of this soil explains the absence of these animals in that zone.

The known altitudinal range is from three hundred feet to two thousand feet, with the greatest abundance at elevations less than one thousand feet.

Habitat

The habitat of *saxatilis* is unique for kangaroo rats. It is characterized by a thin layer of tightly-packed soil, with the underlying rock projecting through in many places, and with large lava blocks scattered over the surface. Over the greater part of the range south of Paines Creek, Tehama County, the topography is broken up by numerous ravines and canyons so that large flat areas are rare.

The characteristic tree of the habitat is the blue oak, *Quercus douglasii*, and this is the only tree to be found over large sections of the range. There are a few digger pines, *Pinus sabiniana*, and still fewer junipers, *Juniperus californicus*. Chaparral is of the hard type, and is represented principally by *Ceanothus cuneatus*.

This plant group is found throughout the northern part of the range, where the subspecies appears to find its optimum conditions. At the upper limits of occurrence, as at the locality six miles southwest of Manton, Tehama County, *Dipodomys* were taken where there was rather dense chaparral and numerous trees. At lower elevations, however, the habitat is more open in nature. On the Abraham Plains, east of Red Bluff, Tehama County, where the subspecies appeared to find nearly optimum conditions, there are practically no trees, and the entire plain is nearly devoid of chaparral.

The southern part of the range has been investigated in a somewhat cursory manner. That part south of the Feather River appears to differ considerably from the northern part of the range in its greater variety of chaparral and trees, and in its deeper soil. *Dipodomys* appear to occur but sparingly in this area, and hence the southern part of the range is probably of less importance than the northern part in its influence on the race as a whole.

Geologically, the habitat is best represented by the exposure of the Tuscan formation, which is seen from Battle Creek southward to Pentz, eight miles north of Oroville, Butte County (*fide* Anderson, 1933). The formation is composed of tuff breccias of Upper Pliocene age, in which erosion of the softer materials has resulted in the accumulation of large blocks on the surface. Since this area includes the most important part of the habitat of *D. h. saxatilis*, as judged by their abundance there, it is taken as typical for the subspecies.

This region is one of sharply marked seasons. Rainfall is almost entirely limited to the winter months, with occasional rain in the spring. Summer and

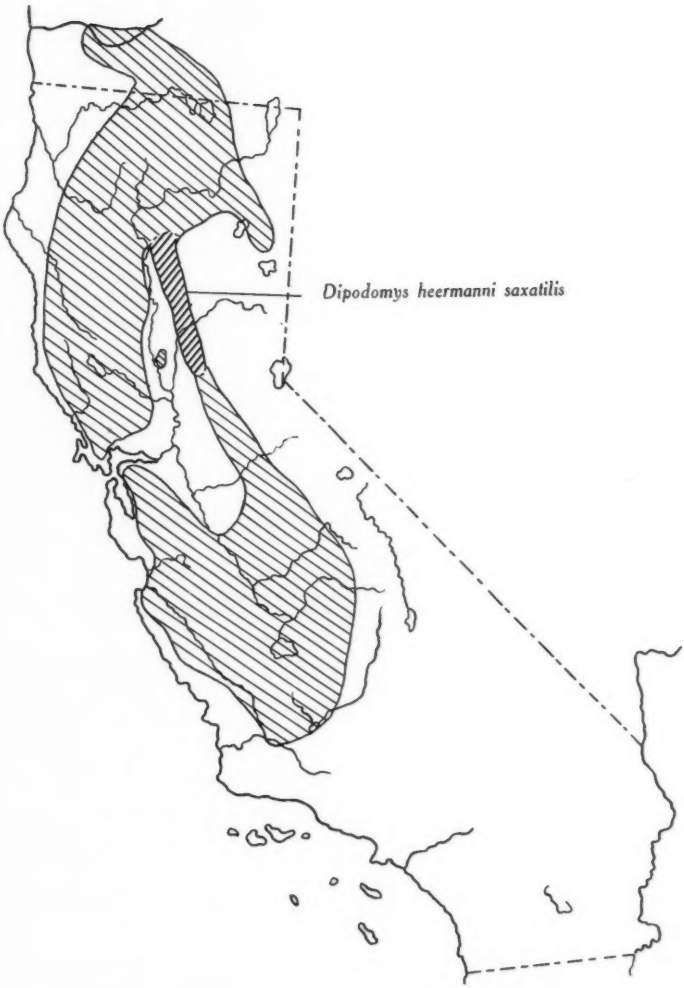

Fig. 1. Map showing geographic distribution of *Dipodomys heermanni saxatilis*, in relation to the range of the species *Dipodomys heermanni* as a whole. Adapted from Grinnell (1922, fig. T, p. 40).

fall are usually dry. In normal years there is but little rain before December, and usually the cold weather in December and January prevents the growth of grass until late in the winter or early in the spring. As a result there is but little green grass except for two or three months in the spring. In dry years the grass is dead by the latter part of April.

The biological aspects of this habitat are chiefly those associated with shallow soil, low rainfall and rapid run-off.

From the standpoint of a burrowing rodent, the shallow soil offers little opportunity for the construction of elaborate homes. It is essential for these animals, over large parts of the range, to adapt their burrowing tendencies to a different type of shelter than those found in environments more nearly typical for the genus. In some places there is an accumulation of soil to a depth of over a foot, but this condition is exceptional. In many places where *Dipodomys* is abundant the soil is not more than six inches deep, with the underlying rock projecting through in spots.

Another feature which affects the biological aspects of the habitat is the extremely rocky nature of the soil. Even where the soil is of a considerable depth there are usually large numbers of boulders scattered over the surface, and many smaller stones throughout the soil.

The boulders on the surface are slaty blue on freshly broken surfaces, but they usually weather to a reddish or brownish shade. Over most of the range studied, the larger rocks, and those firmly attached to the substrate, have a covering of crustose lichens which make them almost black in color. Where there are few large rocks, the predominating color tone of the habitat is reddish, but over most of the area where there are many rocks dark tones predominate.

The uneven surface and shallow, hard-packed soil act together to produce a rapid run-off and quick drying of the ground at the close of the rainy season. This condition is hastened by the fact that the rains are often sudden and severe, most of the precipitation being received in a relatively short time. This condition contrasts with that of the coastal areas where much of the moisture is received in the form of light rains and fogs over a longer time.

The climatic factors and the soil and topographic features of the habitat thus react to produce a flora typical for semi-arid regions. Plants here are for the most part annuals that pass through their life cycles rapidly in order to mature their seed before the dry season. The short wet season acts to produce an abundance of these plants, and the result is large numbers of low, seed producing plants.

Another characteristic of this habitat that deserves mention is its uniformity. From Battle Creek to the Feather River, along the foothills, the same geological formation, flora, climate and topography are found. It would thus be expected that a similar uniformity might be found to exist in the characters of the subspecies occurring in this habitat if the characters are directly or indirectly the product of the habitat.

Distributional Factors

In view of the almost complete restriction of other members of the genus to areas of sandy or light-packed soil, it might be supposed that localities where similar conditions are to be found would be optimum for this race. This is not true. In only one locality where trapping was done, was sandy soil of any appreciable depth encountered. This was near Long's, about one mile southwest of the junction of the north and south forks of Battle Creek. Here kangaroo rats were moderately abundant, but not to the extent that they were in the rocky plains south of Paines Creek.

Optimum conditions, as indicated by the abundance of animals, were found to be most nearly approached on the mesa about eight miles east of Red Bluff (Abraham Plains). There the soil is rocky and shallow. In some places the rock stratum is exposed and there is a covering of large boulders over most of the area.

Light, sandy soil is found principally along the valley floors, particularly along the Sacramento River, and in these places there are no *Dipodomys*. Thus, at first sight, it would appear that *D. h. saxatilis* is not only modified to the extent that it can survive in an environment inhospitable for typical members of the genus, but that it is no longer suited to a habitat normal for *Dipodomys*. This is, of course, merely apparent, and it can be shown that the territory occupied by this race provides a habitat more nearly typical for *Dipodomys* than does the sandy territory in the bottom of the valley. One aim in this study of distributional factors was to isolate those that appear to be critical in determining the fitness of the habitat, and by comparison of these factors with those of the more nearly normal habitat to attempt to determine what features are most fundamental in limiting the range of the genus.

Grinnell and Linsdale (1929) believed the chief factor limiting these animals to the rocky slopes above the valley floor to be the poor drainage and consequent water soaked condition of the lower lands. This factor of excessive moisture may be an important one in restricting the spread of *Dipodomys*. It is undoubtedly the principal cause of decimation over large areas in severe winters such as that of 1937-38, and it has been observed repeatedly that places with adequate drainage are preferred in the optimum habitat. It is true, nevertheless, that *D. h. saxatilis* is surprisingly tolerant of moist conditions. Even in the well-drained slopes, where these animals are quite successful, the soil is wet to the underlying hardpan for practically the entire rainy season. It is not unusual to find that burrows have been cleaned out after heavy rains and to note that the excluded material has been thrown out in the form of mud. Upon occasions I have trapped these animals on rainy nights, and once I caught four on a night on which six inches of snow fell.

It is true also that the ground squirrel, *Citellus douglasii*, is abundant in much of the lowlands, and it was reported by Grinnell, Dixon and Linsdale (1930) that the closely related *Dipodomys h. californicus* on the western side of the Sacramento River utilized the burrows of this rodent in the winter.

D. h. saxatilis could probably use the same method to find dry conditions below the depth to which water penetrates if moisture were the sole factor in the bottom lands.

Moisture is a factor, and at times an important one, in restricting the range of *Dipodomys*. Probably it is usually associated with other limiting factors in its effects.

Plant Cover

No specimens of *D. h. saxatilis* have been taken in lush vegetation in the course of this study, although in several instances traps were set in areas where the grass was tall and dense.

The effect of vegetation may be exerted in at least two ways on kangaroo rats. It provides (or fails to provide) the particular food required, and it plays an important part in the surroundings within which the animal acts. In either capaacity, vegetation may be an important limiting factor to the distribution of *Dipodomys*.

In the early spring, a few specimens of *D. h. saxatilis* have been taken with their cheek pouches filled with green material. Occasionally the pouches were filled with small bulbs. The great majority with food in them contained seeds, and the green material in at least two instances was the young buds of plants, once of *Arenaria* sp., and once of some member of the mustard family. It seems probable that a species adapted to the utilization of seeds to the extent evidenced by this animal would have considerable difficulty in subsisting on the less nutritious stems and blades of grasses and other plants.

The plants of the bottom lands in the region inhabited by *D. h. saxatilis* are chiefly of the type which produce relatively little seed but much stem. In contrast, the plants of the hard-packed slopes are of the type that produce much seed and little stem. This factor probably accounts in part for the preference exhibited for the slopes.

The effect of vegetation, of the general environment of the animal, may be fully as significant as its influence on food. The difficulty in evaluating it is evident from its intangible nature. Possibly the saltatory mode of locomotion is a development correlated with the small amount of food in the deserts in which these forms appear to have originated, and the consequent wide-ranging habits which they were forced to adopt. The instincts and morphological characters accompanying this development would then put the kangaroo rat at a disadvantage in the dense cover so essential to some of the scampering kinds of rodents.

Dipodomys are not intolerant to cover of the hard chaparral type, although some species may not be found in this habitat. At Inskip Forebay, specimens of *D. h. saxatilis* were taken at the edge of large clumps of *Ceanothus cuneatus*, and occasionally burrows were found under bushes of this kind. In all instances of this sort investigated, however, there was open space, devoid of vegetation, near the bushes. In nearly all places where specimens were taken, evidence was found of their activity in the open spaces. The animals appear to be restricted to places where open areas are available.

Vegetation is thus an important factor in limiting the spread of *Dipodomys,* whether it acts by its effect on food or by influencing the general surroundings of the animal.

Availability of Homes

It is often said that *Dipodomys* requires light soil because of its weak digging equipment. What is actually implied is that *Dipodomys* requires conditions favorable to the construction of homes. *Dipodomys deserti,* living as it does in light sand, must construct rather extensive burrow systems to provide safety from enemies. *D. h. saxatilis,* inhabiting an area that is not conducive to digging, is able to find safety with a minimum of excavation. An area with neither diggable soil nor other means of providing shelter would obviously be unsuited to *Dipodomys.* Soil is an essential factor in its influence on vegetation, in its relation to moisture, and in many instances in its relation to home construction. It cannot be said, however, that soil of any particular type is a requisite for the presence of the genus *Dipodomys.* Availability of homes of some type *is* essential.

Within the range of *D. h. saxatilis* there are a few places where burrows can be constructed much as in the habitats of other races. The areas investigated in which kangaroo rats were most abundant, however, offered safety in the form of large boulders beneath which homes could be excavated with little effort. The part of the range immediately north of Paines Creek, at the type locality for the subspecies, appears to be relatively unsuited to *Dipodomys* because of the lack of this factor. Here, in addition to shallow soil, there is a scarcity of large boulders beneath which shelter might be found. The result of this combination is a relative scarcity of *Dipodomys,* although other favorable factors appear to be present here just as in the area south of the creek where *Dipodomys* are abundant.

Dusting Places

The question of the importance of dust to the welfare of *Dipodomys* is one that must be answered by inference, if at all. It is unlikely that an area could be found with climatic factors and soil conditions favorable to the production of the seed plants upon which *Dipodomys* depends but which is devoid of dust throughout the year. Probably a habit as characteristic for these animals as dusting has considerable significance, even though there may be no dust available in the winter months.

Dusting probably removes parasites, and possibly is involved in psychological reactions of the animal in some manner. Howell (1932) mentions that *Dipodomys* deprived of fine sand became unkempt in a short time, and he stresses the importance of sand as a means of removing fatty materials from the pelage.

Whatever the purpose of dusting may be, it is noticeable that dusty trails or roads in an area where *Dipodomys* are abundant become centers of congregation for these animals. Dust or fine sand thus appear to be essential in the habitat of kangaroo rats.

Habits

The present investigation is by no means a life history study of *Dipodomys*. Facts reported here about habits are chiefly those derived from trapping data, although there have been a few opportunities to observe the actions of kangaroo rats at night, and one animal has been kept under observation for about a year. Wherever possible, the attempt has been made to relate the habits to the habitat.

Evidence of Presence

The presence of *Dipodomys* is most easily detected in summer when there is dust. At this time, any dusty trail in the vicinity of kangaroo rat burrows will usually bear numerous imprints of their long, sweeping tails. These imprints are seldom straight for more than a few inches, and often double back sharply, as if the animal were dashing about in play.

Occasionally the prints of the hind feet can be found. These are easily identified by their size and shape, even without the added evidence of the ever-present tail mark. The entire track is narrow at the heel, with a broad pad anteriorly. They are usually from 35 to 40 or more millimeters in length, a little shorter than the actual foot measurement because the heel seldom is placed on the ground. Most often only the ball of the foot shows in the track, and the animal in making the tracks can be said to be semi-digitigrade. Evidently the front feet are seldom used in locomotion.

Nearly always there are so many tracks that it is impossible to measure individual leaps. In one instance a series of tracks was found in which the hind feet were placed evenly, and the individual jumps were about six inches in length. It is evident that this animal was traveling leisurely. No tracks have been measured which gave an indication of the length of leaps when the animal was frightened, but it is evident when they dash across the road in the beam of automobile headlights, that they do not make long leaps. In fact, they appear almost to scamper at such times.

Apparently the saltatorial ability of *Dipodomys* differs considerably among the various species. Howell *(op. cit.)* records leaps of *D. spectabilis* as long as six or eight feet. Grinnell (1937) measured the tracks of *D. deserti* made while the animal was being pursued, and found the leaps to average about twenty-three inches. The longest leap made in this instance was 760 mm. (about 30½ inches). Hatt (1932) reports the maximum leap measured by him for *D. merriami*, under laboratory conditions, to be about nine and a half inches. No exact statement can be made as to the ability of *D. h. saxatilis* in this respect, but it appears to make short leaps. This would be expected in view of the rocky nature of its environment.

Pathways are usually evident in favorable places, as is characteristic of *Dipodomys* of other species. These pathways are not as sharply marked as are the runways of *Microtus*, but evidently indicate merely the routes most often followed by the kangaroo rats when leaving their burrows. When they connect two burrows, these paths are usually distinct for the entire distance,

but where they radiate from the mouth of the burrow toward foraging areas they are usually distinct near the burrow and fade out in a short distance.

Another indication of the presence of *Dipodomys* is the fecal pellet. Where these animals are abundant, there are usually large numbers of pellets along the pathways and especially at dusting places. The individual pellets are about five to six mm. in length and two to three mm. in thickness, slightly curved, and tapered at both ends. All I have seen were black in color.

Homes and Territories

From what has been reported earlier in the present paper, it can be seen that the homes of *D. h. saxatilis* differ somewhat from those of other kangaroo rats. Because the typical home of *saxatilis* utilizes the protection of a large boulder, that type will be described first. The following description of a home and territory is from field notes taken near Longs, about 1 mile SW the junction of the north and south forks of Battle Creek, December 21, 1936.

The burrow is located under the overhanging edge of a boulder about a meter long. It goes out of sight after following along the edge of the rock for a short distance. There is an accumulation of droppings near the opening. Faint, but easily distinguishable runways extend in opposite directions from the opening. One of these goes to an elevated region about 10 meters across, and about 2 meters from the burrow. On this elevation there is considerable evidence of activity. There are a good many scratchings and shallow pits that seem to have been refilled with dirt. None of these seems to have any store of seeds. The largest is no more than the size of a hand. There are quite a few droppings in them, and they may be dusting places.

In the other direction a faint path leads to a rock under which there are three openings. These show evidence of having been cleaned out recently. Between these two rocks, and both in and out of the path, are small bare areas that often contain droppings. The two rocks are about 11 meters apart. Farther yet from the first-mentioned boulder is another small rock, not much larger than a man's head, beneath which is a burrow opening. Beyond this a faint trail leads to a dry water course with sandy banks along which there is much evidence of activity. There are shallow holes in the packed sand, and one which seems to be the opening of a burrow.

I traced this back, running my fingers into it and breaking it out at the top. It ran just beneath the surface and terminated in a store of seeds and hulls (about a handful) tightly packed into the end of the burrow. The deepest part of this system is little more than two centimeters, and the length of the burrow is about three meters.

This entire territory covers an expanse of about 50 meters, and seems to represent a unit of fairly concentrated activity.

This description of a territory is essentially what might be written for any of a great many in the rocky parts of the animals' range. In a sandy area a short distance from the territory described above, kangaroo rats were constructing another type of home, as described on January 9, 1937.

I made a trip for two or three hundred meters to the north of this place this morning and found a good many homes of *Dipodomys*. These are similar to the one described from near here, except that there are no rocks, and the burrows are dug in little knolls in the open. Two or three were on level ground, but always with drainage afforded by nearby ditches. Some of these systems seem too large to be used by a single *Dipodomys*. One, in particular, had three sets of holes in a line, but with runways

branching from each of these so that the area covered must have been 2500 square meters.

One noteworthy fact about all the burrows investigated was their shallowness. This is, of course, necessary in many places because the soil is shallow but appears to be a characteristic of the animal even in places where the soil is deep enough to permit digging to greater depths.

Food

The seed-eating nature of *Dipodomys* is well known, and *D. h. saxatilis* is no exception in this respect. Nearly all specimens whose cheek pouches contained food had been collecting seeds. Occasionally small bulbs were found, and more rarely a few grass stems were included. For a time in the spring *Dipodomys* seem to prefer green material, and some specimens taken at that time have the cheek pouches crammed with greens.

Grinnell (1932) noted this apparent preference for green food on the part of *D. ingens* in the spring, and thought it might be correlated with the time of bearing young. With *D. h. saxatilis*, however, any such correlation would be one of chance, because the grass becomes dry before the height of the breeding season has passed. Some young, but relatively few, are born in the period when there is green grass.

It may be that the preponderance of green material taken by kangaroo rats at this time results in part from the shortage of other kinds of food in the spring. The stores of seeds laid away the preceding summer probably are low by this time, and possibly this "lowness" hastens the change to green food in the spring. It must be admitted, however, that the difficulty found by Grinnell in trapping *Dipodomys* with dry bait at this time has been experienced with *D. h. saxatilis*, also. It is thus possible that the change in food is by preference rather than because of necessity.

Nearly all the specimens investigated in the present study were taken between May and December, and thus did not yield much information on the selection of food in the spring. For the period represented by the specimens at hand, dry seeds make up the bulk of the food taken.

Because kangaroo rats do not hibernate, it is supposed that they store food. No large stores have been found in the present investigation, and the manner in which *D. h. saxatilis* stores food has not been observed. In a few instances, accumulations of seeds and hulls have been found mixed with dirt near the mouths of burrows, and small stores of seeds and hulls have been found in four nests.

The actions of a captive specimen are suggestive in this respect. When given seeds, this *Dipodomys* fills his cheek pouches, digs into the loose dirt, deposits the seeds, covers them with dirt and tamps this down with quick movements of the front feet. The next load of seeds may be buried in a different part of the cage.

Little can be determined from captive animals that can be applied with certainty to animals living in nature, but their actions are suggestive of the method of despositing seeds reported for *D. ingens* by Shaw (1934).

Breeding

Unfortunately for the collection of breeding data, most of the specimens used in this study were taken in the fall. Nevertheless, some specimens were collected in every month of the year except July and August, although the first four months are poorly represented by adult females. Embryos have been found in all months for which specimens were available except January, October, November and December.

Table 1. Showing embryos by months.

Month	Number of Adult Females	Number with Embryos	Per cent with Embryos	Average no. of Embryos
January	2	0	0	0
February	1	1	100%	2
March	1	1	100%	2
April	4	2	50%	3
May	11	9	82%	3.11
June	17	6	35%	2.16
September	35	1	3%	2

The above table gives the data collected with reference to breeding. It can be seen that the low numbers make the averages of but little value for the first part of the year, and yet the fact that four of the six adult females collected in February, March and April contained embryos make it appear that this period is an important part of the breeding season.

No embryos were found in the seven adult females collected between June 12 and 20. This number is small enough for chance to play a considerable part, but compared with the high per cent of occurrence in the preceding month may be significant. It implies, at least, that the height of the breeding season is passed by the middle of June.

The average number of embryos per female is suggestive, if not conclusive. It appears that the highest number of young per litter occurs in May. Two females in that month had four embryos each, and only one of the nine pregnant females taken in that month had two; the remaining six contained three each. If April and May are considered together and compared with the remaining months in which embryos were found, the results are still more striking. Of 11 sets of embryos in these two months, only one contained as few as 2 embryos, and the average is 3.1 per set. Of the 9 sets occurring in other months, only one had as many as 3, and the average is 2.1 per set.

The average for the entire group of pregnant females is 2.65 embryos each, with extremes of 2 and 4. This is somewhat lower than indicated for *D. ingens* by Grinnell (1932), who found four pregnant females, each containing five embryos, and reported one instance of six embryos. The number

of embryos in *saxatilis* is probably about average for *Dipodomys*. Grinnell (1932) gave the usual number in this genus as two or three.

It is not unusual to find pregnant females that show evidence that they are suckling young. It thus appears that at least two litters of young may be born in a season.

D. h. saxatilis, as judged by its breeding behavior, is about as successful in its habitat as are other kangaroo rats, and is evidently more so than *D. ingens*, which, although it appears at first sight to occupy a habitat more nearly typical for *Dipodomys*, must reproduce at a more rapid rate to maintain itself.

Activity

Dipodomys h. saxatilis, like other members of its genus, is nocturnal. No specimen has been seen active in the daytime in this study, except when they have been exposed by overturning stones beneath which they were taking refuge. They begin their activities soon after dark, as evidenced by eleven seen along about a half-mile of road near Abraham Plains, east of Red Bluff, at seven-thirty in the evening of September 26, 1937. No evidence has been accumulated as to their activity in the later part of the night, although specimens have been taken from traps in the morning while they were still limp. This evidence is worth little, however, because they may remain alive in the traps for some time.

Trapping records on rainy nights indicate that these animals are less active then than on clear nights, although specimens have been taken on nights when considerable rain fell. Seventy traps set in the rain in a place where *Dipodomys* were known to be abundant, on October 2, 1937, failed to take any specimens. On this night, however, the rain was unusually severe, and many of the traps floated some distance away from the places where they were set. On two nights, *Dipodomys* were seen crossing the road in the rain.

Cold weather may retard the activities of kangaroo rats, but they appeared fairly active at Longs in the cold winter of 1936-37. One was taken on January 9, when the temperature went to about 12 degrees above zero, Fahrenheight. The tracks of kangaroo rats were seen on snow several times this same winter.

Characters

Dipodomys heermanni saxatilis is a dark, medium sized, four-toed kangaroo rat of the "broad-faced" type. The skull is relatively little inflated in the mastoidal region, and, correlated with this feature, the breadth across the bullae is slight, and the interparietal is wide. The rostrum is broad and of only medium length.

The dark color-tones of *saxatilis* are correlated with a dark substrate, and it is difficult to conceive of other factors generally thought to influence depth of pigmentation as operative in this instance. It has been stated earlier that the climate in which the subspecies lives is arid. Kangaroo rats of the subspecies *californicus* occur near Red Bluff, separated from *saxatilis* by the

Sacramento River and a narrow strip of cultivated land. Although the climatic factors appear identical for these two forms, the race on the western side of the river, occupying a habitat devoid of the black lava blocks characteristic for that of *saxatilis*, is noticeably lighter than in the latter race.

Kangaroo rats of the same species from Lava Beds National Monument are slightly darker than *saxatilis*. All other specimens in the Museum collection from nearby areas are lighter. It is probable that the dark color of *saxatilis* is but a response to the dark tones of its unusual environment.

With the possible exception of the little-known *D. h. eximius*, individuals of *saxatilis* are the smallest of the species. The small size of the subspecies, as compared with the related races adjacent to it, may be a response to the low, warm habitat which it occupies.

The smallest race of any species of *Dipodomys*, *D. nitratoides exilis*, and the two largest forms, *Dipodomys ingens* and *D. deserti*, all occur in the Lower Sonoran Life-zone and at altitudes as low as 300 feet above sea level. Therefore, the factor of altitude alone appears to be insufficient to produce a large or small form. Within the single species, *heermanni*, however, there is a correlation between size and altitude that suggests a causal relationship. The largest members of this species are those from the plateau of northeastern California and the mountainous north central and northwestern part of the State. The smallest are those from relatively low country, i.e., *saxatilis*, *eximius* and *dixoni*. Specimens of *californicus* from the Sacramento Valley are small, approaching *saxatilis* in this feature, while those from the higher altitudes are considerably larger.

Altitude is not, of course, a single factor from the point of view of its biological effects. Temperature and rainfall both change with higher altitudes, and there is a very definite change in geological features between the foothills and the higher Sierra Nevada in that section near the range of *saxatilis*. Probably the correlation is actually with the decreased temperature in the higher altitudes, and is merely an example of the known tendency for closely related warm-blooded animals to be larger in the colder parts of their range.

The four-toed hind foot of *D. h. saxatilis* is one of the features that first suggested the value of the subspecies for study. *D. h. californicus* which ranges to the north and west of *saxatilis* has four toes although, as noted by Grinnell (1922, pp. 39-40), some specimens, in the northwestern part of its range, have five toes. The race *D. h. heermanni* with four toes occurs to the south of *saxatilis* whose range intervenes between that of *heermanni* and *californicus*. Thus to understand the relationship between these forms, it was necessary to investigate the nature of the hind foot in *saxatilis*.

Briefly stated, no specimen of *saxatilis* has been found with five toes on the hind foot. In this character, then, the subspecies does not present an intermediate condition between *californicus* and *heermanni*.

More knowledge would be required of the extent to which the first toe occurs in *californicus* to be able to compare the condition with that of *saxatilis* satisfactorily. It seems that the absence of this digit has become stabilized to

a greater degree in the latter subspecies than in *californicus*. It is not impossible that the loss has been hastened by the hard-packed substrate on which *saxatilis* lives.

The "broad-faced" kangaroo rats are those in which the maxillary arches are relatively widespread. It is possible to express the relative width of this part as a ratio of the length of the skull, but a ratio which is more easily noted in observation of shape of skull is the maxillary breadth related to the breadth of skull across the bullae. In *saxatilis*, which exhibits an extreme in this respect, the skull, excluding the rostrum, is nearly square. In a few specimens the maxillary breadth is as great as the breadth across the bullae. In contrast to this condition, the maxillary spread in the "narrow-faced" type is usually between 80 and 85 per cent of the greatest breadth of the skull.

When fully adult specimens are selected, the relative spread of the maxillary arches is an important diagnostic character. There does not appear to be any significant correlation between this character and any environmental factor, the broad-faced character appears to be rather a heritable feature common throughout a natural group.

All kangaroo rats have the auditory and mastoidal bullae inflated. The northern subspecies of *D. heermanni*, however, have these bullae less inflated than do the five-toed subspecies to the south. It is difficult to judge the degree of inflation in skulls of different sizes, but it is possible to observe the effect on the interparietal bone. This bone is narrow in subspecies which have a high degree of inflation, as in *D. deserti*, for example, where it is almost entirely obliterated by the enlargement of the mastoidal bullae. *D. h. saxatilis* has a wide interparietal, correlated with a low degree of inflation of the bullae.

Another effect of inflation is the increased size of the auditory bullae. In *saxatilis*, the part of the auditory bulla anterior to the external auditory meatus in small, and is not extended anteriorly in a prominent angle as in those related forms with greater inflation.

Grinnell (1922) noted a correlation between large bullae and small ears in *Dipodomys*, although he recognized that there are exceptions. *D. h. saxatilis* is an exception, in that the ear, although about medium in size, is relatively smaller than in *californicus* which has a greater degree of inflation of the bullae.

The habitat of *D. h. saxatilis* is somewhat intermediate between the open desert type, where there is little obstruction, and a chaparral type of habitat where both sight and sound transmission are obstructed. The lava blocks must obstruct the vision of kangaroo rats to some extent, yet they permit greater visibility overhead than does chaparral. They probably do not have much influence on the conduction of sound waves. Grinnell *(op. cit.)* found the correlation between large pinna and the chaparral type of habitat to be high. In this respect, *D. h. saxatilis* is not an exception. Its habitat is more nearly open in nature than that of *californicus*, and this is accompanied by a smaller pinna.

Howell (1932) implies that the greatly inflated auditory bullae of kangaroo rats may be less for the purpose of improving the effectiveness of receiving

sound waves through the air than for receiving vibrations through the ground. If this is correct, a kangaroo rat living in a stony habitat, such as that of *D. h. saxatilis,* would not require bullae as large as would those forms inhabiting soft soil where enemies would be able to approach more quietly.

Measurements

All skull measurements were made with dial calipers, to the nearest tenth millimeter. External measurements were made at the time of skinning the animals, and were taken to the nearest millimeter. Because of the relative inaccuracy of external measurements it is not wise to base important conclusions on slight variations between specimens measured by different collectors. For this reason, only the specimens collected by one collector, myself, are included in the table of external measurements.

Skull measurements.—Total length is the greatest distance, parallel to the axis of the skull, between the anterior tip of the nasals and the posteriormost point of the mastoids.

Basal length is the distance from the anterior surface of the incisor to the ventral lip of the foramen magnum. Length of nasals is the distance, parallel to the axis of the skull, between the anteriormost tip of the rostrum and the posteriormost extension of either nasal.

Breadth across bullae is the greatest breadth of the skull across the auditory bullae.

Maxillary breadth is the distance between the postero-lateral angles of the maxillary arches.

Interorbital breadth is the least distance between the dorsal margins of the orbits, posterior to the lacrimals.

Breadth of interparietal is the breadth of this bone at the posterior margin of the parietal.

Breadth of rostrum is the greatest breadth of the nasals anterior to the premaxillaries.

Breadth of alveolar process is the breadth of the maxillaries across the roots of the first molars.

External measurements.—Total length is the length from tip of nose to the tip of the tail, excluding terminal hairs. Specimens were flexed but not stretched, and care was taken to prevent the skin of the tail from slipping beyond the vertebrae when measurements were taken.

Length of tail is the length from the base of the tail, bent at a right angle to the back, to the tip with the same precaution taken as in total length.

Body length is the total length less tail length. This value is derived by computation rather than by measurement.

Length of hind foot is the distance from the heel to the tip of the longest toe, including the claw. The foot was pressed down on the ruler to cause full extension in this measurement.

Measurements, with standard error, standard deviation, and coefficient of variability are reported for adult and subadult groups in tables 2 and 3.

TABLE 2. Showing mean, standard error, standard deviation and coefficient of variability for measurements of adult males and females.

Males (48 specimens)	mean in mm.	standard error	standard deviation	coefficient of variability
Body length	113.2	.508	3.37	2.98
Length of tail	179.6	1.37	8.00	4.75
Length of hind foot	41.9	.188	1.24	2.96
Length of skull	37.59	.122	.83	2.21
Basal length	26.87	.078	.53	1.97
Length of nasals	14.31	.065	.45	3.14
Breadth of bullae	22.98	.068	.47	2.05
Maxillary breadth	22.29	.093	.63	2.82
Interorbital breadth	12.06	.065	.45	3.69
Breadth of interparietal	2.44	.049	.34	13.77
Breadth of rostrum	4.17	.027	.18	4.41
Females (44 specimens)				
Body length	110.66	.608	3.89	3.50
Length of tail	176.56	1.33	7.88	4.46
Length of hind foot	41.1	.323	.95	2.07
Length of skull	36.96	.079	.52	1.40
Basal length	26.39	.061	.40	1.52
Length of nasals	14.16	.052	.35	2.46
Breadth of bullae	22.59	.067	.43	1.93
Maxillary breadth	21.94	.082	.54	2.45
Interorbital breadth	12.05	.062	.41	3.36
Breadth of interparietal	2.50	.056	.36	14.56
Breadth of rostrum	3.97	.027	.18	4.50

TABLE 3. Showing mean, standard error, standard deviation and coefficient of variability for measurements of subadult males and females.

Males (37 specimens)	mean in mm.	standard error	standard deviation	coefficient of variability
Body length	108.3	.712	3.70	3.41
Length of tail	177.97	1.74	10.44	5.87
Length of hind foot	41.59	.180	.90	2.14
Length of skull	36.7	.120	.72	1.96
Basal length	26.26	.090	.54	2.06
Length of nasals	13.89	.07	.43	3.10
Breadth of bullae	22.44	.088	.53	2.37
Maxillary breadth	20.92	.081	.48	2.30
Interorbital breadth	11.79	.063	.38	3.29
Breadth of interparietal	2.49	.051	.31	12.29
Breadth of rostrum	3.85	.028	.17	4.42
Females (32 specimens)				
Body length	106.3	.648	3.66	3.45
Length of tail	177.73	1.82	10.00	5.62
Length of hind foot	40.81	.265	1.50	3.67
Length of skull	36.25	.139	.80	2.25
Basal length	25.93	.081	.46	1.79
Length of nasals	13.78	.065	.37	2.70
Breadth of bullae	22.14	.084	.47	2.14
Maxillary breadth	20.63	.064	.37	1.80
Interorbital breadth	11.61	.063	.37	3.14
Breadth of interparietal	2.44	.070	.41	16.60
Breadth of rostrum	3.81	.029	.17	4.47

Variability

The characters of *D. h. saxatilis* are relatively constant over a large area. In this respect it can be considered a uniform race. Furthermore, the genus *Dipodomys* is a remarkably uniform taxonomic unit. Nevertheless, there is considerable variation in this form, as in any other group of organisms.

Secondary Sexual Variation

Some rodents, *Thomomys* for example, exhibit a high degree of secondary sexual variation, especially in size and skull characters. *Dipodomys*, on the contrary, shows little sexual dimorphism. No skull characters other than size have been found in the present study which set off one sex from the other, and the size difference is not constant.

Nevertheless, there is a significant average size difference between males and females. In body length, for example, males from south of Paines Creek average 113.2 mm. Females from the same population average 110.66 mm. for this measurement. All average measurements taken are larger in males than in females (see tables 2 and 3). Proportions are about the same for the different skull measurements in the two sexes. For example, the average breadth of the maxillary arches is 97.0 per cent of the breadth across the bullae in the adult males, as compared with 97.1 per cent in the adult females.

Adult and subadult groups differ from one another in proportions to a greater extent than in size. These two groups are carefully selected on the basis of the general stage of development, but represent what would ordinarily be considered as adult specimens in taxonomic treatment. The adult group, of this investigation, is composed of old animals, in which the teeth are in an advanced stage of wear. A group composed of specimens with as great an age span as is represented in these two groups (not an unusual occurrence in taxonomy) would include individuals with a significant degree of variation in both size and proportion directly attributable to age (see table 4).

Individual Variation

Among specimens carefully selected for uniform age and sex there is still a large amount of variation. For example, the smallest body length found in the adult males is 105 mm., the largest measurement is 124 mm. The nine individuals with the greatest body length in this series are all over 115 mm. The seven smallest are 110 mm., or less.

The least total length of skull in the adult males is 35.8 mm. The greatest is 38.9 mm. If the five largest skulls of this series are compared with the five smallest skulls, the extent of variation is even more striking. The average length of the larger group is 38.66, as compared with 35.94 mm. for the smaller. Since it is common practice among taxonomists to compare small series, and to designate as distinct subspecies, forms differing no more in size than these two groups, the possibility of naming forms from chance selection of aberrant individuals of populations nearly identical in structure is not remote.

The extent of variation in proportions is fully as great as that in size. The

relative length of the tail is often used as a diagnostic feature. In the series of males, the greatest relative length of tail is found in number 79664, in which the tail is 181 per cent of the body length; the least relative length of tail is exhibited by number 70336, in which the tail is 140 per cent of the body length.

The relative breadth of the maxillary and mastoidal parts of the skull is an important diagnostic feature in kangaroo rats, and the average for this proportion is nearly identical in males and females. Number 79673, female, has the maxillary breadth of 101.3 per cent of the breadth across the bullae. In number 79723, female, the proportion is 93.1 per cent.

The variability of the different measurements made in the investigation is reported in tables 2 and 3, and will not be discussed individually.

Dipodomys is probably no more variable than most rodents, but the extent of individual, secondary sexual and age variation is sufficient to make it essential to compare relatively large series that are carefully selected for uniformity in age and sex in order to determine the measureable characters of a geographic race.

TABLE 4. Showing mean skull measurements of four age groups and the per cent of increase over the next younger group for the last three.

	Total length of skull	Basal length	Length of nasals	Breadth of bullae	Maxillary breadth
			Males		
Juvenal	32.8	23.3	11.5	20.8	18.1
Young	35.2	25.2	13.2	21.8	19.9
	7.3%	8.2%	14.7%	4.8%	9.9%
Subadult	36.7	26.3	13.9	22.4	20.9
	4.3%	4.4%	5.3%	2.8%	5.0%
Adult	37.6	26.9	14.3	23.0	22.3
	2.5%	2.3%	2.9%	2.2%	6.7%
			Females		
Juvenal	31.8	22.7	11.2	20.3	18.0
Young	35.1	24.9	12.9	22.0	20.0
	10.4%	9.7%	16.0%	8.4%	11.1%
Subadult	36.2	25.9	13.8	22.1	20.6
	3.1%	4.0%	7.0%	0.5%	3.0%
Adult	37.0	26.4	14.2	22.6	22.0
	2.2%	1.9%	2.9%	2.2%	6.8%

DEVELOPMENT

Tooth structure.—In the youngest specimens examined, the deciduous premolar is well developed and, although not worn extensively, does not show the cusps clearly. There is an anterior cusp, which has already lost its enamel covering at the tip, and a posterior U-shaped loph, opening buccally. Even at this early stage there is no evidence of cusps on the loph. The intermediate portion connecting the transverse arms at the lingual margin is somewhat

thinner, however, which indicates that there may have been distinct ridges at an earlier stage of wear.

Wood (1935) figures the deciduous premolar of *D. ordii,* in which the two transverse lophs are distinct. No specimens of *D. saxatilis* in the series studied are young enough to show this condition, but a quite young skull of the closely related *D. h. californicus,* no. 20253, approaches it closely. Two specimens of *D. ordii columbianus,* nos. 51919 and 51920, evidently represent still younger stages than that seen by Wood. In these, the upper premolar bears a small style-like cusp on the anterior margin and two transverse rows of cusps, the first bearing two, and the second bearing three. Between these two rows is an enamel-covered valley, deeper at the buccal margin than at the lingual. Wearing away of the surface results in the union of the cusps in the transverse rows, and eventually in the junction of the two at the head of the valley, which condition exists in the specimens of *D. h. saxatilis.*

A still younger specimen of *D. m. merriami,* no. 17105, with the second molar barely erupting, shows the same structure in the milk premolar as that described above. In view of the close similarity among these specimens from different species, it appears probable that the same basic pattern of six cusps would be found in all members of the genus if sufficiently young animals were studied.

The cusp pattern of the upper molars is not so easy to decipher as that of the premolar. None of the specimens studied shows the cusp structure clearly enough for me to be certain whether the original pattern of the tooth is of five or six cusps. At any rate, the cusps are arranged in two transverse rows with a valley between, much as are the two posterior rows of cusps in the deciduous premolar. The result of wear is much like that in the premolar. Early in life there is a U-shaped trough of dentine surrounded by enamel, and opening buccally. The enamel-floored valley between the arms of the trough is below the grinding surface, as seen from the crown side, and slopes slightly to the buccal margin.

The result of this condition is the gradual widening of the trough with wear, and eventually, after the enamel of the valley floor is worn away, the obliteration of the inner enamel wall to leave a single cylinder of enamel surrounding the tooth. This process does not entail a break at any stage in the enamel covering of the tooth, except as it is worn away at the crown.

Wood *(op. cit.)* describes the cheek teeth of *Dipodomys* as being highly modified toward efficiency by the thinning out and finally the disappearance of the enamel at the lingual and buccal borders to form enamel breaks. He believes this to be in the interest of removing all superfluous enamel.

It appears to me that this interpretation is incorrect, at least in respect to *D. h. saxatilis.* In this subspecies the apparent enamel break in the molars is the natural process of the wearing away of the crown of a complex tooth. It leads to a simplification, and results in a complete enamel ring in the adult tooth.

The process of thinning of the enamel on the crown is carried farthest in

the third molar. In this tooth the cusps are never complete in *D. h. saxatilis* but are merged into transverse troughs without a complete roofing of enamel.

Changes in Development

The characters here given for the different age groups are determined from the combined series from Abraham Plains and Dale's, south of Paines Creek.

In the selection of age groups, tooth development and the degree of wear on the cheek teeth were used almost exclusively. Absolute size is unreliable in determining relative age, except for young specimens for which there are many other additional characters to indicate relative age. For example, number 81992, a mature male, has a small skull of 26.6 mm. basal length, as compared with 27.3 mm. for the same measurement in an immature male, number 34565. Relative size of parts of the skull can be used as a guide in allocating specimens by age, but it was believed advisable to use a single criterion for this purpose in the present study, in order to test the behavior of the parts of the skull in development.

Although the rate of wear on teeth is not constant—it depends on the kind of food and other factors not at once apparent—nevertheless, for the purpose of segregating specimens into relative age groups the amount of wear has been a satisfactory criterion. No specimen has been found in which the degree of wear on the cheek teeth has been noticeably inconsistent with the general development of the skull.

Young skulls are characterized by rough, pitted bone, which contrasts sharply with the smooth bone of adults. Networks of impressions of blood vessels across the bullar portion of the skull give a somewhat wrinkled appearance to this part of the bone.

The finest-textured bone, resembling that of the adult skull, is on the ventral side of the auditory bullae, the dorsal side of the nasals, the rostral part of the maxillary and premaxillary, and in four centers on the dorsal surface of the brain case, one in each of the parietals and frontals. These areas are apparently the first centers of bone formation.

Conversely, the roughest bone is found in the mastoidal bullae and the zygomatic part of the maxillary, which are evidently the last parts of the skull to become fully ossified.

The youngest series studied are specimens in which the deciduous premolars are still retained, and relatively unworn. Ten females and eight males representing this stage of development, here termed juvenal, were measured and studied for individual and sexual differences.

In addition to the characters given above, these juvenal skulls are short, broad and highly arched on the dorsal surface. The greatest length of skull averages 32.8 mm. in the males, and 31.8 mm. in the females, approximately 87 per cent of the same measurement in adult skulls.

The breadth across the bullae is relatively greater than in adult skulls, being 89.3 per cent of the basal length in the males and 89.4 per cent in the

females, on the average, for the juvenile series. The skulls with the greatest relative breadth within these series are the youngest, as for example, number 70339 and 82005, in which this ratio is 93.1 per cent. The specimen with the least relative breadth, 86.0 per cent, is apparently the oldest of the series. It is apparent that the great relative breadth of quite young skulls decreases rather rapidly with increasing age.

Hall (1926) reports, in tabular form, the same trend in the ratio of mastoidal breadth to occipitonasal length in ground squirrels, in which young animals, more than 15 days old, showed a general decrease in this ratio with increased age. Allen (1894) shows a striking decrease in the relative width of the brain case from quite young to very old wood rats.

It is perhaps of some interest that *Dipodomys*, which exhibits unusual development of the mastoidal region, undergoes the same general processes in the development of the skull found in these other rodents. This change in proportions is undoubtedly to be attributed, in part at least, to the rapid increase in length of skull which occurs typically in development, and seems to have no phylogenetic significance.

Change in interorbital breadth parallels that of the mastoidal breadth in a general way only. The youngest skull possess the greatest relative interorbital breadth, but the correlation between this ratio and age is not high with any narrow range of ages. For example, in the youngest age group, skull number 82027 has the smallest relative interorbital breadth (43.7 per cent), yet it appears to be one of the youngest of the series and has a relatively wide mastoidal region (90.4 per cent). There are other specimens in which the correlation breaks down, and the difference between young and old skulls in this respect is but one of averages.

The breadth of the alveolar process of the maxillary is nearly as large in young specimens as in adults (7.0 mm. in both males and females); consequently, the ratio of this measurement to the basal length is somewhat greater in juvenals than in adults. The average for eight males is 30.1 per cent; that for ten females is 30.8 per cent.

Breadth of rostrum changes in development in about the same proportion as does the length of the skull, so that the individual variation in the ratio for this measurement is as great as, or greater than, age variation. The average for the males is 3.4 mm., or 14.6 per cent; for the females, 3.4 mm., or 15.0 per cent.

One of the most significant variants with respect to age is the maxillary breadth, or spread of the maxillary arches. This measurement is exceptional among those of breadth, in that it is relatively, as well as actually, least in young specimens. The correlation with age is not high in the ten females of the series studied, which represent a quite narrow range with respect to age. It is somewhat higher in the series of eight juvenal males. As will be seen when comparison is made with series of older animals, the differences are quite significant when comparing specimens of more widely differing ages.

This measurement is 18.1 mm., or 77.5 per cent in males; and 18.0 mm., or 79.3 per cent in females of the juvenal series.

Since the relative maxillary breadth varies directly with age, while the relative mastoidal breadth varies inversely, the ratio of the maxillary to the mastoidal breadth gives a more sensitive measure of age than either of these expressed as a ratio of the basal length. In fact, this ratio has been found to afford a quick means of assigning specimens to age groups, although further check has always been made by study of tooth development and other characters to test the validity of this ratio as a criterion. In these juvenal skulls the maxillary breadth is 87.1 per cent of the breadth across the bullae in males, and 88.7 per cent in the females.

The nasals are relatively short in young specimens. In the males of the juvenal series they average 11.5 mm., or 49.4 per cent; in the females they are 11.2 mm., or 49.4 per cent.

The interparietal is extremely variable. The range in width of this bone is from 1.5 to 3.1 mm. in the small series of juvenal skulls, with the average about the same as that for the adults; thus the relative breadth of the interparietal is, on the average, greatest in young skulls.

The second age group includes skulls in which the permanent premolar is not as yet at the level of the molars, but the milk teeth, if still present, are well worn. Of this group there is a series of 17 males and another of 15 females. They will be designated as young, as opposed to juvenal skulls in the first group.

The characteristics given above for juvenal skulls hold to a lesser degree for those of the young group. The bone is still rough and pitted, though not to as great a degree as in the juvenal skulls. The dorsal surface of the brain case is still strongly arched, but this character is also expressed less strongly in the young skulls.

The increase in length over the juvenal specimens is considerable, although I feel sure that the difference in age is slight between these groups, probably no more than two weeks or a month on the average. Young males have a skull with an average length of 35.2 mm. This is larger than that for the juvenal skulls by 2.4 mm., or 7.3 per cent. In the young females, the difference is somewhat greater, being 10 per cent more than in the juvenal specimens.

The increase in breadth across the bullae is less than that in length of the skull, resulting in a relatively narrower skull. The average difference between juvenal and young males in this measurement is 1 mm., or 4.8 per cent of the breadth in the juvenal males. The average difference between females of the two groups is 8.3 per cent.

Maxillary breadth increases more rapidly than either the mastoidal breadth or the length of the skull. The average difference between the young and juvenal males in this measurement is 10 per cent of the breadth in the juvenal specimens, and the difference in the females is 11 per cent.

The greatest difference measured between the juvenal and young skulls is in the length of nasals. The young males differ from the juveniles by 14.7

per cent, and the young females by 16 per cent in the average length of nasals.

Thus the most significant changes noted in young skulls, as compared with the juvenal, are the following: (1) The length of the skull has increased more than the breadth across the bullae, resulting in a relatively longer and narrower skull, (2) the maxillary arches have become relatively as well as actually wider as compared to length, and especially to mastoidal breath of the skull, (3) the nasals have increased more rapidly than the length of the skull, (4) the dorsal surface is less strongly arched than in juvenal skulls, and (5) the bone has become firmer and smoother.

The third age-group is composed of specimens which are nearly as large as adults, but which differ from the oldest group in the lesser degree of wear on the cheek teeth. Nearly all these specimens were taken in the fall, and probably represent animals born the preceding spring. They are thus about three to five months in age. They are in adult pelage, and would be considered as adults in usual taxonomic procedure. They are termed subadult in the present report. The series from which the characters for the subadult group are determined consist of 37 males and 32 females.

These skulls resemble older specimens in most features, although the smooth, firm texture of the bone is not as yet fully attained. In specimens prepared by the use of Dermestid beetles, as at the Museum of Vertebrate Zoology, this feature of the bone is a reliable criterion for judging the relative age of specimens. When skulls have been boiled, and especially when chemical reagents have been added to the water in which they are cooked to hasten the cleaning process, some of the minerals are often removed, and the appearance of the adult skulls is then similar to that of the subadults or young animals.

The trends in development exhibited by younger specimens continue in the period represented by the age difference between young and subadult skulls. Subadults have longer, relatively narrower skulls, on the average, than do the young animals, and the arched condition of the dorsal surface is not so apparent. The average length for the subadult males is 4.2 per cent greater than the same measurement in the young males, while that for the subadult females is but 3.1 per cent greater than for the young females. This low per cent of increase in length between the young and subadult, as compared with the greater increase between the juveniles and young animals, is notable, in view of the greater age difference between the two older groups. Evidently the rate of increase is much more rapid in the younger groups than in animals more than a month old.

The breadth of the audital part of the skull is but 85.4 per cent of the basal length, on the average, for both males and females of the subadult group. The average maxillary breadth is 79.7 per cent of the basal length in each sex, and the ratio of the maxillary breadth to the mastoidal breadth is 93.1 per cent in females, and 93.4 per cent in males.

Thus the signficant changes noted in the size and proportions of the skull

from young to subadult are as follows: (1) a relatively small increase in size (as compared with the rate in younger animals); (2) greater increase in length than in breadth, resulting in a relatively narrower audital region, and (3) greatest increase in the maxillary part of the skull, causing the part of the skull posterior to the rostrum to be more nearly square as viewed from above.

The adult series are compsed of 48 males and 44 females, all of which have the cheek teeth well worn. The youngest of these specimens are probably about a year in age; those taken in the fall are believed to be, for the most part, animals that were born in the spring of the preceding year, and that are thus about 18 months or more in age.

The average size of the adult skulls is but little more than for the subadults, and the relative breadth across the bullae is about the same. The nasals are a little longer, relatively and actually, and the maxillary arches are considerably broader. The last-mentioned character is the most significant difference noted between the subadult and adult skulls. The ratio of the average maxillary breadth to the breadth across the bullae is nearly identical in males and females of the same age group, and the combined measurements for both sexes give an average for 92 adults of 97 per cent, as compared with 93 per cent for the 69 subadults.

The above-mentioned trend toward firmer and smoother bone in the older specimens evidently continues beyond the subadult stage, as the firmest bone is found in the adult skulls.

Taxonomy

The race *saxatilis* shares with the other closely related kangaroo rats of California north of the waterway comprised in the San Francisco Bay, the Sacramento River and the Middle Fork of the American River, two features in which it differs from the remaining races of the species *heermanni*. The mastoidaal bullae and the remainder of the auditory bullae are relatively little inflated, and the hind foot bears only four toes instead of the five customary for the southern forms of this species.

The inflation of the bullae is a feature of degree, and is a character of the kind most often associated with subspecific, rather than generic, differentiation. Nevertheless, the northern forms, with slight inflation of the bullae, differ so markedly from the southern races of the species, in which the bullae are strongly inflated, that they appear to constitute a natural unit in this respect.

The number of toes on the hind foot is ordinarily given considerable weight in taxonomy. The loss of a toe is a more fundamental change than usually is thought of as accompanying the differentiation of a subspecies, and the number of toes on the hind foot was formerly used to distinguish two genera of rats, *Dipodomys* with four toes and *Perodipus* with five.

In contrast to the above mentioned characters that appear to set off the northern forms as a unit, there are other features that indicate a close relationship of all the races now classified under the species *heermanni*. The wide-

spread maxillary arches have been discussed earlier in this report. The uniformity of this character within the *heermanni* group, and the contrast between these forms and the narrow-faced rats, imply that the character is of considerable importance, especially since this feature appears to be entirely unrelated to the habitat in which the animals live. Other features of the maxillary and rostral part of the skull agree in detail, such as the anteroposterior width of the maxillary arch (which is great in both groups), the broad rostrum, and the general shape of the anterior part of the skull, all of which I take to indicate close relationship. Also the distribution of these forms is complementary.

Late in the investigation I found it difficult to accept the interpretation made by Grinnell (1922) that these northern forms should be considered as subspecies of *heermanni*. When the stable nature of *saxatilis* became known it appeared still more unlikely that this interpretation would suffice. The one adult specimen from near Cool, Eldorado County, at the southernmost locality represented in the Museum collection for *saxatilis*, is as typically a member of that race as are specimens from the type locality, far north in Tehama County. Furthermore, the fact that the characters of *saxatilis* are extremes rather than characters intermediate between those of *californicus* and *heermanni* made it appear almost conclusive that the two groups deserved specific separation.

In November, 1938, four specimens were obtained 7 miles west and 3 miles south of Placerville, Eldorado County, and they are intermediate in characters between *saxatilis* and *heermanni*. These specimens bear the first toe and claw of the hind foot, and are thus referable to *heermanni* on the basis of that character. In size, on the contrary, they are about average for *saxatilis*, and are about intermediate in the degree of inflation of the bullae.

Although intergradation has not been demonstrated in the number of toes on the hind foot, the otherwise intermediate nature of specimens from a locality geographically intermediate between the previously known ranges of *heermanni* and *saxatilis* indicates that intergradation is to be expected in all features somewhere in this area.

If intergradation does occur, and these forms are no more than subspecies of the same species, then a character as fundamental as the presence or absence of a toe can serve to differentiate between subspecies. Thus, the characters that differentiate between subspecies appear to be of the same kind as those which set off the higher categories.

If complete intergradation does not occur, and these forms are actually different species, the distribution and obvious close relationship between them leave little, if any, doubt that their origin was from geographic races of a single species.

Although the treatment of these forms as distinct species would be desirable for convenience, in placing together subspecies that clearly form natural groups within the present species, *heermanni*, the criterion of intergradation

indicates that they should be treated as subspecies of one species. Thus the interpretation made by Grinnell *(op. cit.)* is substantiated in the present investigation. The two kinds, with their type localities, should stand as:

Dipodomys heermanni saxatilis Grinnell and Linsdale, Mesa near Dale's, on north side of Paines Creek, 700 feet altitude, Tehama County, California;

Dipodomys heermanni heermanni Le Conte, Sierra Nevada, California (according to Grinnell, 1922, "probably in Upper Sonoran Zone on Calaveras River, Calaveras County").

Conclusions

1. The fundamental factors favoring the distribution of the genus *Dipodomys* are (1) arid or semi-arid climate, (2) proper drainage, (3) any combination of soil and climatic factors to provide an abundance of seed plants with light cover, (4) some provision for shelter, and (5) the availability of dusting places for at least a part of the year.

2. The apparently unique habitat of *Dipodomys heermanni saxatilis* does not differ essentially in these fundamentals from the more normal habitat of kangaroo rats, although it differs strikingly in details.

3. The uniform nature of the habitat in which this subspecies lives is matched by the uniformity of the animals. The subspecies does not show any indication of a cline, and is not intermediate in its characters between the races on either side. Probably the diagnostic characters of the subspecies are responses to the envrionment in which it lives.

4. The simple molar teeth of the adult develop from a complex pattern by the wearing away of the crown. There are no "enamel breaks" in the adult tooth of *D. h. saxatilis*.

5. Growth of the skull is most rapid in early life. The juvenal skull is short, broad and highly arched. The chief changes in proportion made in growth are the relative lengthening of the skull, relative lengthening of the rostrum, and the relative broadening of the maxillary arches.

6. The variability of skull characters is sufficient to raise serious doubt as to the value of averages based on small numbers, even when the specimens measured are carefully selected for sex and age.

7. Males are, on the average, larger than females for every series measured. There are no apparent differences in proportions of skull in the two sexes.

8. Although the kangaroo rats of the northern part of the State appear to form a natural unit, differing in their characters from the southern forms more than they do from one another, there is good evidence for intergradation between *D. h. saxatilis* and *D. h. heermanni*. Hence the northern forms are included in the species *Dipodomys heermanni*.

9. The inclusion of four-toed and five-toed kangaroo rats in a single species is an indication that the characters separating subspecies may in kind be of the same nature as those commonly used to distinguish higher categories.

REFERENCES

ALLEN, J. A. 1894—Cranial variations in Neotoma micropus due to growth and individual differentiation. Bull. Am. Mus. Nat. Hist. **6**:233-246, 1 pl.

ANDERSON, C. A. 1933—The Tuscan formation of northern California with a discussion concerning the origin of volcanic breccias. Univ. Calif. Publ. Bull. Dept. Geol. Sci. **23**:215-276, 13 figs. in text, pls. 17-21.

GRINNELL, J. 1922—A geographical study of the kangaroo rats of California. Univ. Calif. Publ. Zool. **24**:1-124, 24 figs. in text, pls. 1-7.

———1932—Habitat relations of the giant kangaroo rat. Journ. Mammalogy **13**: 305-320.

———1937—Mammals of Death Valley. Proc. Calif. Acad. Sci. (4th ser.) **23**: 115-169.

GRINNELL, J., J. DIXON AND J. LINSDALE. 1930—Vertebrate natural history of a section of northern California through the Lassen Peak region. Univ. Calif. Publ. Zool. **35**:1-594, 181 figs. in text.

GRINNELL, J. AND J. LINSDALE. 1929—A new kangaroo rat from the upper Sacramento Valley, California. Univ. Calif. Publ. Zool. **30**:453-459, 1 fig. in text.

HALL, E. R. 1926—Changes during growth in the skull of the rodent Otospermophilus grammurus beecheyi. Univ. Calif. Publ. Zool. **21**:355-404, 43 figs. in text.

HATT, R. T. 1932—The vertebral columns of ricochetal rodents. Bull. Am. Mus. Nat. Hist. **63**:599-738, 27 figs. in text, pls. 11-20.

HOWELL, A. B. 1932—The saltatorial rodent Dipodomys: The functional and comparative anatomy of its muscular and osseous systems. Proc. Am. Acad. Arts Sci. **67**:377-536.

SHAW, W. T. 1934—The ability of the giant kangaroo rat as a harvester and storer of seeds. Journ. Mammalogy **15**:275-286, 1 fig., pls. 9-10.

WOOD, A. E. 1935—Evolution and relationship of the Heteromyid rodents with new forms from the Tertiary of western North America. Ann. Carnegie Mus. **24**:73-262, 157 figs., 4 tables.

Observations on the Life History of the Red Squirrel in New York

W. J. Hamilton, Jr.

The red squirrel *(Tamiasciurus hudsonicus)* and related species occurs in one form or another over much of northern United States and Canada. One finds, with little search, an extended bibliography relating to the habits of this species. The most elaborate study is Hatt's (1929) monograph, which not only includes much of our present knowledge of the life history of the species, but adequately summarizes the studies of earlier naturalists. Both Klugh (1927) and Seton (1928) have made many pertinent observations. However, when these are consulted, we find many gaps in our knowledge of this interesting species. It is for this purpose that the following observations have been assembled and recorded. Emphasis is placed on those factors in the life of the squirrel which have been studied least. It is not improbable that the observations on habits made in central and western New York are similar to those in other parts of the squirrel's range having similar climate and habitat.

Measurements, Weights and Moults.—The average measurements of 20 adult males from Ithaca, New York, are: total length 312.3 mm.; tail 120 mm.; hind foot 46 mm. Eight females average slightly smaller, thus: total length 302 mm.; tail 122.6; hind foot 45 mm.

The weights of 18 adult male squirrels taken throughout the year at Ithaca average 182 grams. The heaviest weighed 216 grams and the lightest male 126 grams. Fifteen adult females, with embryos, if present, removed, averaged 187 grams. The heaviest weighed 208 grams and the lightest, a small gravid individual, weighed but 146 grams.

The seasonal change in coat color from the olivaceous and dull reddish pelage of summer with black lateral band, to the bright rufous of winter is effected by a semi-annual moult. Hatt (1929) remarks that the winter coat begins to show wear and thinning in late April and May, although there is little color change at this season. The moult is apparently completed by early August. According to this author, the autumnal moult commences in November and while complete by the end of December, the color of the coat does not reach its peak of intensity until February or March. In another month the color starts anew.

My observations in central New York are quite complete on this phenomena. It is often possible to approach a squirrel within a few feet where my observations have largely been made. From January to late April the winter coat is evident on practically all squirrels I have observed. A male taken in Cattaraugus County, New York, on April 29, 1936 had new fur on the head, fore feet, several large patches on the neck and back and the hind feet. This was the most advanced moult for this early date I have seen. Usually a few

squirrels show incipient moult on the fore limbs, the hind feet and the belly during this period. The most advanced moult for this time was a large squirrel collected on May 9, 1936 in which the summer pelage had replaced that of the winter fur on the entire fore feet of the body, the latter remaining only on the rump and tail. By late May most squirrels show some moult; it is well advanced by the first week of June. On June 5, 1932 I shot two squirrels, one of which had the winter fur remaining only on the inner side of the hind limbs and about the anal region. The other squirrel had new fur on the belly, face, fore limbs, hind feet and a small patch the size of a raspberry in the middle of the back. The moult is normally completed by late June. I have seen only one individual which retained a part of the winter fur into July.

The summer pelage is worn until October or early November. Often during mid-October a squirrel is collected which shows incipient moulting along the mid-dorsal strip of the back, or the new fur may often appear first on the shoulders and fore feet. Several squirrels taken during mid-November have had all but the face clothed in the new winter pelage. Practically all the squirrels in central and westren New York have obtained their complete winter livery by early December, but the bright red dorsal pattern does not become fully lustrous until January.

Records of live trapped animals during intervals of the fall suggest that about six to eight weeks is necessary for the complete moult.

Reproduction

General observations of several writers (Mearns, 1898; Preble, 1908; Seton, 1929; Dice, 1921; Klugh, 1927, Hatt, 1929) indicate that the red squirrel in widely separated parts of its range (Alaska to New York) mates from early February to late March. Little is recorded on the length of the breeding season or the number of littlers produced. Klugh (1927) remarks on half grown young seen in early September:

> These late occurrences of young may possibly indicate a second brood, though, if this is the case, it is certainly the exception and not the rule.

The following data on the breeding habits of red squirrels were made chiefly about Ithaca, New York, although additional records are available from the eastern and northern part of the state.

Mating Behavior.—I have little information which would suggest that either promiscuity, polygamy or monogamy rule. Both Seton (1909) and Klugh (1927) present scanty evidence that the species is monogamous, and that males do not tolerate another of the same sex in the neighborhood of their chosen mates. Meagre observation in central New York suggests the red squirrel is promiscuous.

The few matings I have observed have been forceful ones, the male pursuing the female and mounting her as soon as she is overtaken. During the late winter the frequently observed chasing and scampering about in trees of these squirrels is a prelude to the rough mating act.

Season of Reproduction.—Males have been noted with enlarged pendulous

scrotums as early as January 12, although those collected during the first two weeks of January for several years had no sperm in the cauda epididymis. The earliest animals containing sperm were taken on January 20, and two of three animals collected on January 28, 1929 had greatly enlarged testes which contained abundant and active spermatozoa. Throughout February, March and April the males have descended testes which almost invariably contain quantities of sperm. The testes usually decrease in size during June but may enlarge again during July. Specimens collected during September often have abundant spermatozoa, while a single 209 gram male collected on October 12, 1931 had active spermatozoa in the epididymis. Thus the males are apparently capable of fruitful mating over a long period, perhaps for eight months, although the majority have descended testes only during the late winter, spring and early fall.

The earliest record of mating in central New York is on February 12, 1938. On that date I collected a female with a large turgid vagina which contained quantities of sperm. Inasmuch as I have several records of nursing females collected during the first week of April, it would appear that, if these produced young during the last week of March, conception probably occurred during mid-February. These are the earliest breeders; the majority first mate during early March and partus normally occurs during April. Some litters are produced in early May, for several lactating squirrels have been collected during the first week of June.

Mating occurs in July, several pairs having been observed *in coitus* during this month. That such attempts are not abortive nor sporadic is indicated by the presence of embryos in females taken during this month and several nursing females which have been shot or found dead on the highway during mid-August.

A red squirrel was collected on September 29, 1937 at Ithaca which contained five 10 mm. embryos, and another taken on the same day was nursing, her uteri indicating by their enlarged, but relaxed walls that she had quite recently borne young. Further evidence of September breeding is confirmed by several litters observed during mid-October. Three young squirrels, whose estimated age was set at 50 days, were collected on October 19, 1936. Lyon (1923) records the probability of two litters in Indiana.

Inasmuch as the males are found with enlarged testes containing sperm several weeks earlier than females with embryos, and again later in the fall, it would seem that the female controls the length of the breeding season. This is, in general, in keeping with other small mammals in which the female governs the length of the season of reproduction.

Gestation Period.—The length of gestation has not been recorded for the red squirrel. Dr. Lillian D. Powers writes me that with her captive gray squirrels the gestation varies from 43 to 46 days, with an average of 44 days. From this we may argue from analogy that the smaller red squirrel has a period of about 40 days, possibly slightly less.

Litter Size.—Various authors record from four to six or occasionally seven

young, the observation being based largely on embryo counts. My own record, based on 38 gravid individuals, gives an average of 4.2 embryos per female. In all females which I have examined, the embryos have numbered from 3 to 5.

Of 9 litters observed about Ithaca, the young have always numbered four or five.

As to the number of litters produced each season, Hatt (1929) remarks:

> The young, of which there appears to be but one litter a year, are usually born in April, May or June, but they may be born at any time during late spring or early summer.

Hatt believes that broods born late in the summer may possibly be second litters although his only evidence consisted of a female taken on July 19 in the Adirondacks of New York which contained 5 embryos. The mammary glands were greatly hypertrophied which suggested that they might be following rather than preceding a period of lactation.

Klugh (1927) records young squirrels accompanied by an older one in various parts of Canada during September and October, and believed that these late occurrences of young might possibly indicate a second brood, although Klugh felt such to certainly be the exception and not the rule.

In central New York two litters are not uncommon and it is my belief that most adult females have a spring and fall litter, while there is evidence that particularly virile animals may even produce three litters. In order to secure testimony on this matter, I trapped a number of red squirrels during the entire breeding season of 1935. These were marked by sundry marks in the ear, incising the last phalanx of a toe, etc. and liberated. A female taken of March 25 was obviously heavy with young, and her mammae were noticeably swollen. On August 11 she was retrapped and gave evidence of very recent nursing. On September 26 she was again trapped but succumbed in her frantic efforts to escape. Dissection proved her to be in anoestrous. Another female taken on April 3 was nursing and when shot on September 25, some quarter mile from the original point of capture, contained four 23 mm. embryos. She may have produced another litter during the summer.

Two or even three, litters are what we might expect in the red squirrel when it is known that the gray squirrel and flying squirrel both have two litters per year (Hibbard, 1935).

Development of the Young.—Few observations have been made on the rate of development of young red squirrels. Svihla (1930) made observations on young squirrels born in captivity but having the run of a large cage in a quiet locality. At birth they were blind, pink all over and quite hairless and averaged 7.5 grams. When nine days old a very fine coating of black hair was visible on the back while the hair on the belly was white. The hair on the head became reddish on the thirteenth day and they had the characteristic appearance of a red squirrel when 24 days old. Their eyes opened when 27 days old at which time they averaged 47 grams. These observations are of

considerable value, for they allow one, within limits, to determine the approximate age of nest young. The young squirrels apparently leave the nest within a few days after their eyes open, for I have taken a number which weighed from 50 to 56 grams. Two individuals of a single litter collected on June 2 and June 4, 1939 which I estimated at 7 weeks of age, weighed 57 grams each. Weaning occurs shortly after they first leave the nest, and solid food is taken when they are five weeks old. While I was watching a litter of four young squirrels playing on a large white oak which served as the den tree, one young attempted to nurse the parent, but it was rebuffed with several slaps from the mother.

While I have shot and trapped a number of young squirrels in the fall that were marked in the spring, I have found no evidence that they breed during their natal year. Moreover, there is some evidence that those born late in the season (September-October) often fail to mate during the first breeding period of the following year. This is substantiated by finding a number of barren females during March, April, and May, which, from their weight and skeletal characteristics, stamp them as sub-adult squirrels.

Nests.—In the hardwood forests of central and southern New York, most of the young are born in inside nests, either natural cavities formed by rot or those excavated by flickers and other large woodpeckers. No tree species appears to be particularly favored, although I have found more young squirrels in nests made in hard maples, apples and hickory. Where suitable cavities are lacking, the squirrels construct a substantial nest, roughly globular, from leaves, shredded bark and always the bark of grape where this is available. Often the nests will be placed in tangles of grape vine, and young have been found in such nests on two occasions. In the northern part of New York, the squirrels construct these bark nests near the crown of some dense spruce, or else close against the trunk but usually well hidden from the view of man. Bird boxes are frequently utilized and the young are sometimes reared in nests built in the inaccessible corners of attics or between the studding of old frame dwellings.

Food

All of our tree squirrels are lavish with their food, storing far in excess of what they can eat and frequently consuming only a small portion of each item they collect in times of plenty. Nichols (1927), commenting on the food of the grey squirrel remarks:

> Whatever crop they are enjoying at a given time, be it acorns, seeds, buds, is at that particular time far in excess of their needs. It behooves them not so much to conserve their food as to cultivate a varied appetite and wide knowledge of what is good to eat and where to find it, so that failure of any source at any particular time of year or in any particular year will not find them at a loss as to where else to turn for sustenance.

Red squirrels reach their greatest abundance in the coniferous forests of the north, where they rely chiefly upon the seeds of pine and spruce. Lacking these, they take what buds and seeds, nuts and other edibles they chance upon.

My observations on the food habits of this species have been conducted chiefly at Ithaca, where, about the campus conifers do not predominate. Elms, maples (Norway, silver and sugar) box elder, red and white oaks, hickory and miscellaneous shrubs provide a suitable and varied diet.

During the winter the favorite food appears to be the buds of maple and elm. The squirrels are able to gather these even when stormy weather prevails and other foods are snow-covered. In the slopes of nearby gorges, the squirrels feed almost exclusively on the seeds of hemlock and the mast of white oak, apparently never journeying a few hundred yards to the elms which provide a plentiful supply of food. Buds are the staple food of late winter, although nuts are favorites at this season. A single pignut hickory provided the greater share of food for 9 squirrels for three months during the spring. As the flower buds of elm and maple expand, they are eagerly consumed. Then the flowers are taken, and as the tree seeds, the ground becomes littered with little elm twigs supporting masses of seeds. The squirrel will cut off a small terminal cluster, eat a few seeds and drop the remaining cluster containing dozens to the ground. As the seeds of elm and maple ripen, they are eaten avidly. So abundant are these foods that the squirrels make no pretense at hoarding a supply, but are content to dig them from the grass. By all odds the most important mainstay of the squirrels are these elm seeds. They shower to the ground in such incredible numbers that the squirrels can obtain sufficient numbers for a meal a year after they have fallen.

During the spring red squirrels tap the limbs of maples, making a neat slit on the under surface. On cold April nights the flow of sap forms little icicles which the squirrels eat with evident relish. The rounds of these sap stations are made at regular intervals while the flow persists.

Squirrels apparently secure sufficient moisture from their food without resorting directly to water. I have seen them drinking from the streams which flow through the Campus, but in some regions they certainly have no access to water for long periods. For four weeks in the early summer of 1939 no rain fell, and squirrels thus had no opportunity to secure a drink. I saw a young squirrel lapping at the sap from a wound in a large elm during this period.

Despite the abundance of squirrels in localities favored by nesting birds. there is little evidence that the eggs or nestlings are disturbed. I have watched red squirrels pass repeatedly within 2 or 3 feet of a nest containing fledgling robins and these were not molested. The parent birds do not appear to be unduly alarmed when red squirrels are about. On the other hand, nestling orioles appear susceptible to predation. In may be their incessant and noisy chatter which attracts the attention of squirrels. Dr. O. A. Johannsen believes red squirrels periodically destroy the young of Baltimore orioles which nest about his home.

Squirrel Populations

Most, if not all, small mammals are cyclic; their population varies from year to year. At one time they may appear extraordinarily abundant, occur-

ring in incredible numbers, while a year hence their population has dwindled so there seems scarcely an animal left. The red squirrel is no exception.

In 1927 red squirrels were very abundant about Ithaca, New York. Inquiry in the fall of that year from observers in the western part of the state elicited the same response to the effect that these animals were extremely common. John Pearce (personal letter) notes that these squirrels were extraordinarily abundant about the Cranberry Lake region of the Adirondacks, northern New York, during the fall and early winter of 1927. All the residents of this region agreed the squirrels had "thickened pretty quick" and attributed the increase in squirrels to the decrease in the fisher and marten, which were trapped extensively because of high fur prices.

In central and western New York during 1928 squirrels were less common and by the following year they were noticeably scarce. I made repeated efforts to collect red squirrels during February and March, 1929 but my efforts were largely unrewarded. Squirrels appeared yet scarcer in 1930 but I do not possess many notes for this year. In 1931 and 1932 squirrels increased in numbers and by 1933 the population appeared to be "normal." During 1934 red squirrels increased in numbers, while 1935 was the banner year for this species. All through the late summer, fall and winter one could be certain of seeing a few during a short tramp in the woods. But empire has its fall among squirrels as with men. Squirrels became noticeably scarce in 1936 and every effort to collect a suitable series for reproductive studies was without reward. Surprisingly enough, their numbers did not decline drastically on the Cornell campus, but elsewhere few could be seen, and their characteristic chatter was seldom heard. Their numbers did not noticeably increase in 1937. For two months (June 15 - August 15) I was in the field daily in Albany County, eastern New York, in an area of hemlock, beech and maple, which normally would support a large population of squirrels, and saw only three squirrels during this period. The following summer I spent a month in the same locality and saw only seven squirrels. The red squirrel population has increased in central and western New York during 1939, but the numbers still appear far below those of 1933 and 1934.

It seemed desirable to determine if the squirrel population had fluctuated in this manner over adjacent states. Accordingly, in the summer of 1939 I wrote to several observers in New England, Pennsylvania and parts of New York which I had not had opportunity to visit. The results, listed below, check amazingly well with my own figures, and suggest that the squirrel cycle is not a restricted one, but occurs simultaneously over a wide area.

Massachusetts.—At the Wharton Bird Banding Station, Groton, Massachusetts it has been desirable to keep the squirrel population as low as possible. Red squirrels are removed either by trapping and transporting, or by shooting. Thus the data compiled represents the flowing into this area of squirrels from the outside and assumes that the higher the general population, the greater the pressure on the animals to seek new territory. In 1926 three squirrels were taken; 1927, 4; 1928, 0; 1929, 1; 1930, 3; 1931, 3; 1932, 17; 1933, 8;

1934, 3; 1935, 22; 1936, 3; 1937, 0; 1938, 4. During the first half of 1939 two squirrels were taken. Inasmuch as red squirrels move into the Station to a greater degree during the last six months of the year, this would indicate a higher population than has been present since 1935. This is borne out by observation on other areas. The year 1935 was a peak year, Mr. William P. Wharton having a notation to this effect covering a forest area in the easterly part of Groton.—Edwin A. Mason.

In western Massachusetts the red squirrel is very scarce and in central Massachusetts quite abundant while in the eastern part of the State the number is far below what one would reasonably expect to find (1939).—L. Edward Stroebener.

In north-central Massachusetts, in a region of white pine and hardwoods the red squirrel population is high (year?). In one old pine-hemlock stand of around 50 acres a couple fellows working on a study of fire weather shot 63 red squirrels during one late summer and fall while the cones were maturing. That wasn't the whole population, of course. This was about 1927.—N. W. Hosley.

Vermont.—Most of the observations were taken during the winter and supplemented by other field observations during the spring and summer. Considerable concentration occurs in years of food shortage and a good year brings a general distribution. (The following observations relate to Rutland and Windham Counties). In 1929 red squirrels were plentiful. In 1930 some decrease in numbers was noted. Squirrels were further reduced in 1931. Another decrease was noted during 1932. The bottom of the cycle came during 1933. A slight increase in 1934. Still increasing in 1935. The spring of 1936 was marked by a late frost which was a severe setback to squirrels. The butternut blossoms were destroyed along with the apple crop and beechnuts. Even sumacs were injured so they did not bear fruit. Grey squirrels migrated and red squirrels were down to the danger point. Good recovery was made in 1937. Recovery continued through 1938. So far this year (1939) the population seems to be well distributed and definitely on the increase and can be expected to reach near peak proportions this year or next.—F. L. Osgood, Jr.

New Hampshire.—General increase (1937-38) in red squirrels at the following locations: Pillsbury Reservation, Mill Village; Gale River Experiment Forest, Pierce Bridge; Bartlett Experiment Forest, Bartlett; Norfolk. Also a similar increase over the region as a whole. I found them plentiful enough in the Green Mountains this March (1939). Last year was such a good seed year for conifers here that opportunities to gauge their abundance were excellent. However, I noticed several restricted localities where they were making littl use of the crop and apparently were not at all common.—John Pearce.

Pennsylvania.—In Allegheny National Forest red squirrels were fairly abundant in the summer of 1935. By fall they had increased and were very abundant (considering that this section is not optimum for them, having in my opinion too little coniferous cover as compared with true north woods condi-

tions). — Beginning late in October a drastic reduction in the entire squirrel population took place over the next few months. It began with migrations to the westward. By late November the grey squirrels were uncommonly met with and in the spring of 1936 they were very scarce. The red squirrels did not show so marked a drop but they did go down in numbers. If they migrated, however, it was certainly less apparent than with the grey squirrels as they were still numerous in late November but seemingly less so than earlier in the fall. The red squirrels seemed better able to stand the severe winter. I knew of none being found dead or barely alive as was the case with several grey squirrels during the cold weather. Red squirrel tracks seemed to grow gradually less numerous though and in the spring they were appreciably less abundant than in the fall. — During 1936 both species gained but very little in this section.—John Pearce.

At Beavertown red squirrels were scarce during 1938 and early 1939. Observers saw only five in one year.—Douglas Wade.

Ontario.—At Cobourg, north shore of Lake Ontario there have been only occasional red squirrels since 1933. During that year fifty squirrels were shot and trapped on an area of about ten acres.—Ernest B. Tracy.

New York.—About the Moose River country of the Adirondacks, near Inlet, New York, red squirrels appeared to hold to normal numbers in 1933 and 1934. In 1935 they were extremely abundant and the following year the population was much below normal.—J. Victor Skiff. In this same area the squirrels were scarce in 1937. For 1938 there is only slight evidence, but they seem to have begun to increase again.—Robert W. Darrow. In eastern New York during 1924-25 near Albany, red squirrels could be seen in a favorable habitat any time the observer cared to. In 1926 red squirrels were abundant (noticeably more plentiful than usual) about the Albany area and the Adirondacks. During 1927 the squirrels in these areas were not so evident, but by 1929 they were again abundant. In 1930 and 1933 squirrels were abundant in Saratoga and Ulster Counties. Squirrels were very scarce in Rensselaer, Saratoga, Albany and Columbia counties in 1936, for when the observer sought squirrels they could not be found. No records for 1937, but a few squirrels have been seen in the Albany region during 1938-39 but they do not appear to be numerous.—Walter J. Schoonmaker.

In western New York (Genesee County) the red squirrel is now on the increase. In the summer of 1934, the red squirrel was still fairly abundant in this region, but 1936 appeared to be the low population point.—Ransom I. Page. In the Bear Mountain region of southeastern New York red squirrels have been slowly increasing during the last three years (1937-39) but are still scarce.—Robert H. Wilson.

In summary, we find the red squirrels of central and western New York were extraordinarily abundant in 1927, much less so in 1928, and scarce in 1929. They continued to be very scarce in 1930 but the population increased slowly from 1931 to 1934 when they were abundant. By 1935 squirrels were

very abundant, but the following year they were again very scarce. They continued to be scarce in 1937 but the population showed a gradual but noticeable increase in 1938 and 1939. Moreover, fragmentary evidence indicates that similar populations prevailed throughout northeastern United States.

These data suggest that the red squirrel cycle runs over a period of 8 years. In a study of the grey squirrel of Ohio, Chapman (1938) concludes that this species probably has a cycle of about five years in the Middle West.

The reason for the periodic decline following optimum populations is not apparent. Many naturalists attribute scarcity of squirrels to a lack of suitable food, although McAtee (1936) has shown that such is not a factor constantly functioning in the regulation of populations. By their very lavish feeding habits and adaptability to many different food items, it would seem that squirrels are seldom, if ever, dependent upon a good crop of beechnuts, acorns, or other mast. Epidemic disease probably is the major factor in reducing their numbers when the peak of a cycle is attained. So few occurrences of sickness have been recorded in wild animals that every instance should be recorded.

Early in the spring of 1935 at Bergen, New York, Ransom Page watched a red and a grey squirrel about ten feet off the ground in the same ash tree. Both appeared sick and would hardly move when a stick was thrown at them. After a number of pelts with the sticks they finally crawled to a safe height in the tree. During mid-May of 1936, I captured two adult male red squirrels on the Cornell campus, both of which were so emaciated they could scarcely move. One died within 8 hours of capture and the other succumbed on the following day. A necropsy of the squirrels failed to indicate any major ailment, and the viscera were free of inflammations. Both were heavily parasitized with fleas (37 *Ceratophyllus wickhami* Baker on one squirrel) which undoubtedly through mechanical irritation alone, had added to their misery. During that summer I noted six dead squirrels on the campus highways, which suggests they were less alert than usual, for one seldom sees more than one or two killed by campus traffic each year.

Period of Activity

Hunters generally are familiar with the fact that squirrels are most active in the morning and again toward evening. Several writers indicate that the red squirrel is like other members of its tribe in this respect. Hatt (1929) states that the red squirrel is more or less active throughout the day, although in the forest, during the hottest weather, there seemed to be a temporary decrease in activity about midday.

On several occasions we have made a census of the red squirrel population on the Cornell University campus, both to determine population fluctuations from one year to the next, and learn something of the time at which these animals are most active. Our studies indicate that, while this species may be up and about at all hours of the day, it is much more active at certain periods

than at others. One can observe far more squirrels within an hour or two after dawn and again at dusk than at all other periods of the day.

On October 16, 1936 forty students in our Mammalogy Class engaged in a census and study of the activity of the red squirrel on the campus. The class was divided into two sections of 20 each, one to make the forenoon census and the other section for the afternoon. Each student was assigned an area of approximately five acres, although where the squirrels were known to be more abundant, a smaller area was assigned the individual. Most of the observers were provided with binoculars, although observation was made easy at this season as many leaves had fallen. A record was made of the time at which squirrels were observed, the approximate number of squirrels estimated for the region under observation and the results tabulated the following day.

Another group of 20 students in the wildlife management course made a similar survey during the forenoon of November 12, 1939. These are all

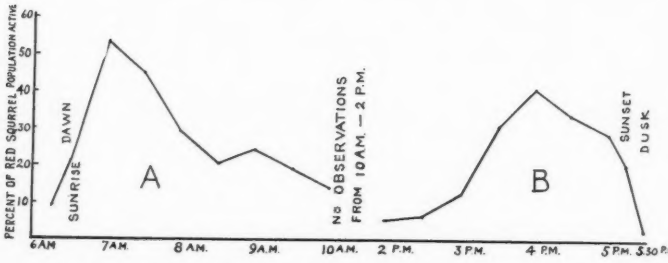

Fig. 1. (A) Activity of red squirrels (estimated 94 squirrels in area studied) on the Cornell University Campus Nov. 12, 1938 as determined by 20 observers. (B) Activity of red squirrels (estimated 78 squirrels in area studied) on the Cornell University Campus Oct. 16, 1936 as determined by 20 observers.

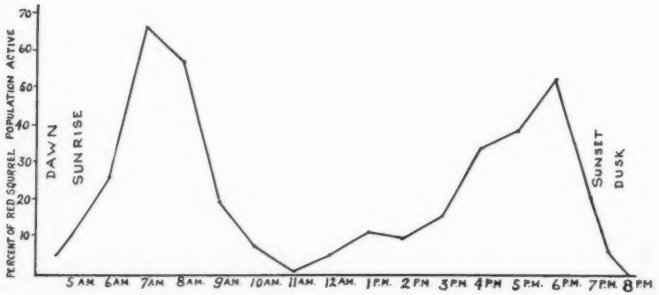

Fig. 2. Activity of red squirrels (estimated 44 squirrels in area studied) on the Cornell University Campus August 5 and 6, 1939 as determined by one observer. In both figures, observations are recorded to the nearest hours.

tabulated in Figure 1. Although no data on activity were secured during the middle of the day, we know, from long observation, that squirrels during the fall are not particularly active at this period.

A similar survey was made on August 5 and 6, 1939 in a somewhat more restricted area, embodying not more than thirty acres. In this area, which supported about nine family groups totaling approximately 44 squirrels, the census was conducted by myself from dawn to dusk on the two successive days. The results are indicated in Figure 2. These observations are further substantiated by general observations of several of my students; from a family of red squirrels which I could observe from my laboratory window, and finally, from detailed observations of one of my students, Mr. John Morse. Other squirrels probably exhibit similar activity as has been shown for the red squirrel. If such is true, one can readily see the advantage of censusing a squirrel population at the proper time, i.e., about sunrise. A good share of the squirrels are active at this period, but if the census is delayed until later in the forenoon, many of the squirrels have become inactive and a fair estimate of their number cannot be made. Wildlife technicians would do well to keep this in mind when making a census of tree squirrels.

During the milder season of the year, inclement weather has little effect on squirrel activity. During the winter, however, storms and prolonged cold spells may cause the squirrels to remain at their dens for some time. Tree squirrels, of course, are non-hibernators,but there is much evidence that they are inactive during prolonged cold and stormy spells of winter. Even though the red squirrel is known to be about at a temperature of –35° F., Klugh (1918) remarks that during very stormy weather squirrels are not seen for two or three days at a time.

On January 28, 1929 several squirrels were seen following a three day period of cold stormy weather in which none were observed. From January 29 to February 4, 1929, snow fell every day although the temperature averaged 15-20° F. No squirrels were stirring during this period. Following a severe snowstorm on January 20, 1936 red squirrels remained inactive for three days and none were seen, although every effort was made to collect a few.

Just before a snowstorm, red squirrels are very active. For three days prior to the blizzard of March 7, 1932 red squirrels were extraordinarily active, storing white oak acorns and hickory nuts in tree cavities and the shallow hollows formed by large limbs meeting with the trunk. At such times, they appear much excited, running about in a frenzy, their tails held at right angles to the ground and bent in a sharp crook at the tip. Grey squirrels likewise exhibit great concern preceding stormy weather, and make every effort to dig up and garner a sufficient store of food to last them during a prolonged period when snow covers the ground. Nevertheless, both species can and do experience little trouble in finding their caches hidden in a shallow excavation of the ground, and sink their subnivean tunnels directly to a store when food is needed.

Territory and Homing Behavior

The home range of the red squirrel is rather restricted, and in areas where sufficient food is found, an acre of territory will suffice. In a three acre oak and maple woodlot near Ithaca six squirrels lived, the offspring moving into new quarters as they matured. On the Cornell campus, two, three or four squirrels usually occupy a clump of maples, spending the greater share of their time in the bounds of an acre. One group of oaks supports eight squirrels, which seldom travel more than a few rods from the trees, yet the area occupied by these squirrels encompasses but half an acre. Gordon (1936) remarks on the circumscribed area occupied by pine squirrels *(Sciurus fremonti),* some individuals seldom occupying an area more than a half acre in extent. He believes the charatceristic churring note of the pine squirrel serves the same purpose as song in the territorial behavior of birds for warning other individuals that the singer was ready to defend its area against invasion.

A number of squirrels have been captured alive and uninjured in Burt can traps, and these have been marked so that they could be readily identified through binoculars. Such observations have further strengthened my belief that the home territory is a restricted one and that squirrels seldom venture far beyond their chosen domain.

In 1931 and 1932 a number of squirrels were trapped, marked and liberated some distance from their place of capture. When removed distances up to three-quarters of a mile, the squirrels usually returned promptly to the original point of capture. One squirrel captured on the campus and removed to a point a mile away was observed on the campus two days later. On the other hand, three which were removed a similar distance from the campus apparently were satisfied with their new quarters, for they were not seen again.

Such observations are easily made and similar experiments should be carried on in more detail. The red squirrel has such a nervous temperament that if left long in a trap it will injure or fret itself to death. Accordingly traps should be visited frequently and any squirrels which have been caught removed immediately. They may be etherized and marked at leisure. A satisfactory manner of marking is to remove sufficient fur from the rump or shoulders to facilitate immediate recognition. The fur will grow in when the animal next moults, but usually such marking remains prominent for several months. A large hole punched in the ear, hairs removed from the middle of the tail and similar markings are likewise evident to the observer for some time after the squirrels have been so marked. Various dyes have been tried without much success. Waterproof red ink painted on the animal's white ventral fur remains evident for a few weeks, but such markings are not always easily observed.

REFERENCES

CHAPMAN, FLOYD B. 1938—Summary of the Ohio gray squirrel investigation. Trans. Third North American Wildlife Conference, pp. 677-684.

DICE, L. R. 1921—Notes on the mammals of Interior Alaska. Jour. Mammalogy **2**:20-28.

GORDON, KENNETH. 1936—Territorial behavior and social dominance among Sciuridae. Jour. Mammalogy **17**:171-172.

HATT, ROBERT T. 1929—The Red Squirrel. Roosevelt Wild Life Annals **2**(1): 11-146.

HIBBARD, CLAUDE W. 1935—Breeding seasons of gray squirrel and flying squirrel. Jour. Mammalogy **16**:325-326.

KLUGH, A. BROOKER. 1927—Ecology of the Red Squirrel. Jour. Mammalogy **8**:1-32.

LYON, MARCUS WARD, JR. 1923—Notes on the mammals of the dune region of Porter County, Indiana. Proc. Indiana Acad. Sci. for 1922: 209-221.

MCATEE, W. L. 1936—The Malthusian Principle in Nature. Scient. Monthly **42**:444-456.

MEARNS, E. A. 1898—Vertebrate Fauna of the Hudson Highlands. Bull. Amer. Mus. Nat. Hist. **10**:303-352.

NICHOLS, JOHN TREADWELL. 1927—Notes on the food habits of the gray squirrel. Jour. Mammalogy **8**:55-57.

PREBLE, EDWARD A. 1908—A Biological Investigation of the Athabaska-Mackenzie Region. N. Amer. Fauna **27**:1-574.

SETON, E. T. 1929—Lives of Game Animals **4**(1):117-149.

SVIHLA, RUTH D. 1930—Development of young red squirrels. Jour. Mammalogy **11**:79-80.

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A Tooth Belonging to the Genus Anomoeodus from the Cretaceous of Maryland

Charles T. Berry

Gidley (1913) described two new species of Anomoeodus from the Cretaceous of Mississippi and later (1926) assigned another fossil tooth to this genus, also Cretaceous in age, but from Tennessee. These two articles by Gidley are the latest dealing with this genus of fish as found in North America. Previous to 1913 Leidy had (1857, 1872) described the teeth of fossil fishes which have since been considered as belonging to the genus Anomoeodus. These four articles comprise the entire literature on the North American representatives of the genus. The present paper is an endeavor to describe an additional find, from Maryland, assigning it as a variety of one of Gidley's species.

On April 24, 1938, the author, while collecting from the Monmouth formation (Upper Cretaceous) at Brightseat, Prince George's County Maryland found the object which is described below. The find consisted of the left splenial of a species of fish belonging to the genus Anomoeodus whose presence is here first reported from Maryland.

Subclass GANOIDEI Agassiz
Order LEPIDOSTEI Huxley
Family PYCNODONTIDAE Agassiz

Anomoeodus latidens marylandicus var. nov.

Fig. 1 a. b.

Description.—Specimen consists of portion of left splenial bone with six more or less perfect large transverse teeth of the principal series. The teeth are smooth although the splenial bone is greatly pitted, there being large conical depressions on the inner edge. The outer margin of the bone rounds down to form a broad protecting edge, as shown in cross section in Fig. 1b. On the inside of this edge there are the small circular markings where six small button-shaped teeth were once located, none of which were more than 2 mm. in diameter, and which were irregularly placed with regard to the large teeth of the principal series. The large transverse teeth, which increase in size posteriorly, are sigmoid in outline. The largest and most complete tooth (which is the fifth) is 21 mm. in width (transverse) and 6.5 mm. long (anteroposterior). The surface of the tooth is flat or very slightly convex while the sides are vertical. Each tooth is separated from the next by a distance of 1 mm. to 1.5 mm. The surface of the teeth show very little wear and that little does not appreciably flatten them, as is shown in tooth number five. The surface of the inside end portion of the teeth curves up as though it had been badly worn in that region. In the first two teeth the ends have

been worn away while in the third the wear has formed an oval hole. The rounding is not due entirely to wear for the splenial bone also curves up in this region. The specimen from Maryland has been designated as *Anomoeodus latidens* var. *marylandicus*.

Remarks.—The North American representatives of the genus *Anomoeodus* comprise *A. mississippiensis* Gidley, *A. latidens* Gidley and *A. phasceolus* (Hay) from the Cretaceous of Mississippi, also *A. robustus* (Leidy) from the greensand of New Jersey and a single tooth from the Upper Cretaceous of Tennessee which has been ascribed to this genus. The type specimens of *A. mississippiensis*, *A. latidens* and the tooth from Tennessee have been carefully studied and it has been found that neither of these three agrees exactly with the specimen from Maryland. The same is true for the short descriptions and measurements of *A. phasceolus* and *A. robustus*, whose types were not studied.

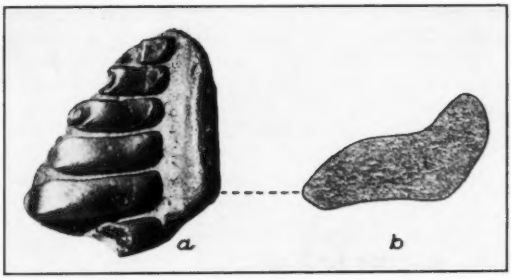

Fig. 1. *a*, Left splenial bone of *Anomoeodus latidens* var. *marylandicus*, x1; *b*, Cross-section of same.

The measurements of the North American species are as follows:

	Length (Anteroposterior)	Breadth (Transverse)
A. phasceolus (Hay)	7.4 mm.	18.5 mm.
A. robustus (Leidy)	9.5 mm.	30.0 mm.
A. latidens Gidley	5.5 mm.	22.0 mm.
A. mississippiensis Gidley	7.5 mm.	24.0 mm.
Anomoeodus sp. Gidley	No measurements	
A. latidens var. *marylandicus* n. var.	6.5 mm.	21.0 mm.

Not only from the five North American species, but also from the European species, the Maryland specimen differs in that the teeth of its principal series increase in width more rapidly toward the posterior portion of the mouth. The individual teeth are more sigmoid in shape and not so tapering at the ends as in the other North American species. In *A. latidens* the individual teeth are more arched in an anteroposterior direction than in the Maryland specimen, regardless of wear. The present specimen differs from

A. mississippiensis in the shape, size, and distance between individual teeth of the principal series. The specimen from the Upper Cretaceous of Tennessee is so incomplete that no comparison can be made.

So far, representatives of the genus *Anomoeodus* in North America have been separated from each other partly by geographic location and partly by the dimensions of the individual teeth. The present author does not feel that there is enough information as to the habits of this fish, such as its ability to migrate, to warrant setting up a new species on geographic location alone. The same is true with regard to the dimensions of the teeth, especially when one considers that the finds are only fragmentary.

Since the Maryland specimen agrees more closely with *A. latidens* than with any of the others, but differs slightly in tooth size and geographic location, the author prefers to make the Maryland specimen a variety of *A. latidens,* giving it the name *Anomoeodus latidens marylandicus*. The new specimen has been deposited in the U. S. National Museum and has received the catalogue number 15,822.

REFERENCES

GIDLEY, J. W. 1913—Some New American Pycnodont Fishes. Proc. U. S. Nat. Mus. **46**:448.

———1926—Description of fishes from the Ripley Formation Tennessee. U. S. Geol. Surv. Prof. Paper. **137**:192.

LEIDY, J. 1857—Proc. Acad. Nat. Sci. Phila. 168.

———1872—Proc. Acad. Nat. Sci. Phila. 163.

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Cyprinodontidae From the Pliocene in Roger Mills County, Oklahoma

J. Willis Stovall and William N. McAnulty

Material and Locality.—In December 1936, several fossil minnows were collected by Donald E. Savage, graduate assistant in vertebrate paleontology at the University of Oklahoma, and the junior writer, on the form of Mr. J. D. Green (NE¼, NE¼, Sec.8, T.2N., R.23W.) five miles south and one and one-half miles east of Cheyenne, Roger Mills County, Oklahoma.

Description of Material.—The description given is based upon examination of ten fairly complete specimens and numerous incomplete ones. The fish are embedded on an inter-lamina plane making it difficult to expose them without splitting into a longitudinal section.

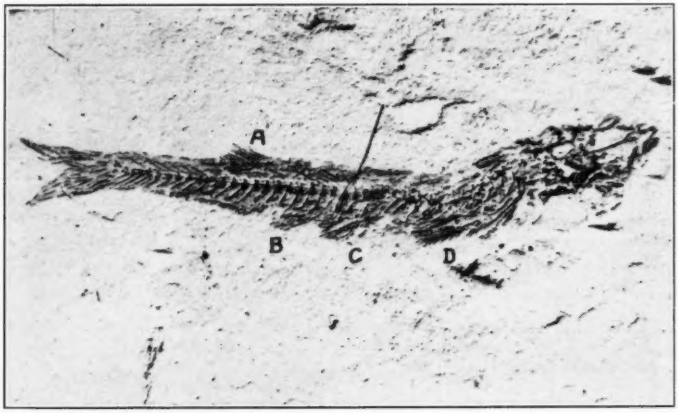

Fig. 1. *Plancterus kansae?* showing the character of the caudal fin and the position of the other median and paired fins. A, dorsal fin; B, anal fin; C, pelvic fins; D, pectoral fins. Reproduction from retouched photograph. Length of specimen 43 mm.

The body is elongate, shallow and nearly straight. A few of the specimens appear to be slightly arched from the occiput to the beginning of the dorsal fin, however, since some are curved dorsally and others ventrally it is probable that this curvature is due to distortion after or during deposition. The average length is 44 mm., the longest being 54 mm., and the shortest 26 mm. The depth of the body is contained in the distance from the tip of the snout to the base of the caudal fin 5.5 times. The caudal fin is homocercal, medium sized, forked, slightly convex, and has from 14 to 20 rays. The paired fins are small and are located in an abdominal position. The dorsal

fin is located just above, or slightly anterior, to the anal fins and has eight fin ray. The anal fins are located slightly posterior to the middle of the animal. The pectoral fins are set very close together and have eight rays. The vertebrae are well preserved and have the typical hour glass shape with two longitudinal grooves on each side. The number of vertebrae ranges from 28 to 30.

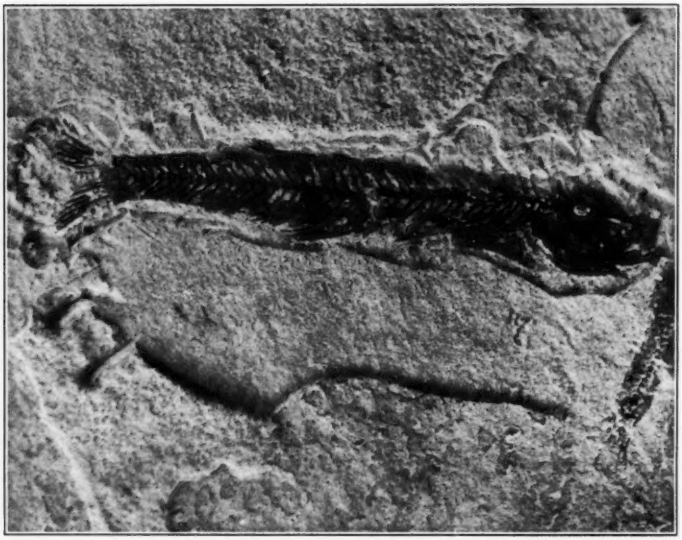

Fig. 2. *Plancterus kansae?* showing general character of the skull, the position of the orbit and the protruding dentry. Made from a slightly retouched photograph. Length of specimen 47 mm.

Many important cranial elements[1] have been distorted or concealed as result of compaction of the containing sediments. The skull is relatively long and narrow, its length being slightly less than twice its depth. Its length is contained in the total length of the fish 3.4 times. The crown is slightly flattened. There is a prominent backward extension of the postero-lateral aspect due to enlargement of the opercular region. The mouth is small and of the superior type due to the protruding dentary. The presence of several medium sized cycloid scales in the skull region indicate that the head was scaled. The orbits are small.

Comparisons.—The writers place these specimens with the Cyprinodontidae[2] because of their strong general resemblance to that group of fishes. However, no strong generic characters of the fossil fish from Roger Mills

1 Gregory, W. K., Fish Skulls: A study of the evolution of natural mechanism. Read Dec. 2, 1932. Trans. Amer. Philos. Soc. n.s. **23**(2):216-224, 1933.

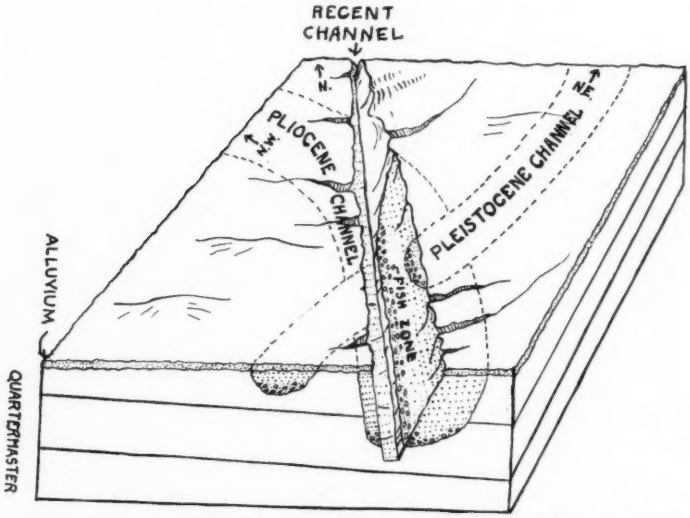

Fig. 3. A diagram to show the relationship existing between the Pliocene fish bearing channel sand and Pleistocene and Recent channels near Cheyenne, Oklahoma.

County have as yet been determined. After a comparative study of recent species inhabiting that area it was found that the fossil form is very similar to *Plancterus kansae*,[3] a small cyprinodont abundant in Western Oklahoma today.

The following comparative table shows the close agreement in characters between *Plancterus kansae* and the specimens described.

	Fossil form	Plancterus kansae
Length (average)	44 mm.	44 mm.
*Skull	3.4	3.3
*Depth	5.5	4.2
Caudal fin rays	14–20	16–20
Anal fin rays	14?	12–14
Dorsal fin rays	8–12	12–14
Pectoral fin rays	8	8–10
Number of vertebrae	24–40	24–34

* Number of times contained in the total length of the fish.

Geology of the Fossil Location.—The fish were embedded in a deposit of soft sand. The beds ranging from 0-15 feet in thickness, are exposed in the banks of a small creek for a distance of one-fourth mile. The trend of the present stream is north-south. Exposures at the north end, 180 feet wide, show the east and west margins, and these together with the position of the foreset bedding, suggest a southeastern trend of the depositional current. The

2 Garman, S. The Cyprinodonts. Memoirs Mus. Comp. Zool. Harvard, **19**(1): 5-18, July, 1895.

3 Pratt, H. S., Vertebrate Animals of the United States, 1923.

beds rest on the Quartermaster (Permian) formation. There are three cycles of erosion involved above the Permian. From the top of the section downward, it is seen that the present south flowing stream cuts an earlier channel filling whose trend is northeast-southwest. This in turn cuts a lower and previous deposit whose trend is northwest-southeast. Thus on the basis of stratigraphic position, a Pliocene age is assigned.

At the base of the strata in which the fish occur is a thin layer of gravel, and above this the beds are composed of fine-grained angular sand in a calcareous clay and silt matrix. In a four inch layer, two feet above the base, and at the bottom of the fish producing strata, are found many lime concretions. Although yellow ocher is the predominant color, the finely laminated layers are variegated, the colors being red, pink, buff, and brown. A secondary blue-gray tint is due to the presence of alternating paper-thin laminae of clay. Two feet above the base there is a three inch layer of hard sandstone. Eight feet above this there is another thin, tightly cemented layer of sandstone.

The fish horizon begins two feet above the contact with the Quartermaster formation and extends upward through the next four feet of strata. Geographically it is situated midway between the northern and southern extremities of the exposure. The upper eight feet of the Pliocene beds are of a looser sand and contain no fossils. Associated with the fish were found many leaves, pieces of wood, at least two species of fresh water ostracods, and a small frog.

A Pleistocene deposit, ranging from 1-12 feet in thickness, rests disconformably upon the Pliocene fish beds. At the base of this upper member is a conglomerate, 1-6 feet thick, composed of quartzite pebbles, flint, scattered lumps of yellow sand, many clay fragments, and a few large water-worn sandstone boulders, suggesting a stream of considerable velocity. The predominant color of this deposit is maroon. The depositional current of this old stream apparently had a northeast-southwest trend.

A deposit similar to the one from which the fish came, is found three miles south and one and one-half mile west of the described locality. One-half mile east and one mile north of the fish location is another such exposure.

From the evidence observed, it seems feasible to conclude that the formation represents deposition either in a series of small Pliocene lakes, a larger, deeper lake or in the protected back-water of one or more streams with rapidly shelving bottoms. The character of the material collected appears to favor lacustrine deposition.

Minnows living in this region at the present time belong to the genus *Plancterus*. The similarity of the ecological background of the fossil and the living forms suggest that they belong to the same genus. While no teeth of the fossil have been found, similarities in total length, ratio of skull length to body length, number of fin rays, position of the paired-fins, and the shape of the caudal fin all appear to indicate that these fossils are of the genus *Plancterus*.

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Book Reviews

NOMENCLATOR ZOOLOGICUS, A List of the Names of Genera and Subgenera in Zoology from the Tenth Edition of Linnaeus 1758 to the End of 1935. Edited by Sheffield Airey Neave, O.B.E., D.Sc. (Oxon.), F.Z.S., Assistant Director, Imperial Institute of Entomology; sometime President and Honorary Secretary of the Royal Entomological Society of London; Membre d'Honneur, Cercle Zoologique Congolais. In Four Volumes, Vol. I A - C. Published for the Proprietors by The Zoological Society of London, Regent's Park, London, N.W. 8, 1939. Advance-subscription rate of six guineas post free for the four volumes. After publication, eight guineas.

The first volume of this important and much needed work has just appeared. It is unnecessary to call attention to its value to all systematic zoologists which is greatly enhanced by the comparatively low cost. It is well made, printed on excellent paper in clear and easily readable type. For the most part each generic and subgeneric name and its place of publication, as well as the zoologic group to which it refers, occupies but a single line, usually about sixty names to a page. The size of the page is 6¼ in × 9⅛ in.; 957 pages. The volume is compact and easily held in one hand. The generic names are brought down from the appearance of the Tenth Edition of Linnaeus' *Systema Naturae* 1758 to the close of the year 1935. It includes all the variants in spelling of each name. It is an excellent piece of work, and the editor deserves a great deal of credit for his painstaking effort.

The preface states "this work will contain rather more than 225,000 entries. Of these about 15,000 are supplementary references, or cross references, leaving a balance of 210,000, of which about 13.8 per cent represent alternative spellings. Consequently, the actual number of names described as representing supposedly distinct genera or subgenera is about 192,000."

"So far as the proportionate representation of the various classes of animals is concerned, the names of the Insecta outnumber the whole of the rest of the Animal Kingdom, and this predominance has become especially marked during the last 40 years. The Mollusca come second, and are followed by the Arachnida. The Crustacea are also a large group, so that it will be realised that the dominance of the Arthropods over the other animals on this planet is complete."

The work covers essentially the same ground as the *Nomenclator Animalium Generum et Subgenerum*, gotten out under the editorship of Franz Eilhard Schulze for the Prussian Acadamy of Science. This pretentious work had the same starting point, but aimed to go as far as the year 1910 only. The project, as may well be imagined, was rudely interfered with by the World War; but after the hostilities ceased publication began bringing the work up to date at the year 1922. The volumes of the German publication are much larger than those of the English, the pages measuring 8 in. × 11¼ in. The names, in small blocks and about 50 to a page, are arranged in three columns instead of a single row, the type is larger, and the volumes themselves can not be so easily handled. At the present time it has been printed through *Trich.* The price of the published parts of the German Nomenclator is about $150, a sum rather prohibitive for the average zoologist, in comparison with the price of the English work. Let us hope that the present war does not interrupt the publication of the British Nomenclator.

It is interesting to compare the cost of the two publications, the total cost of preparation of the English Nomenclator being 1800 pounds; that of the German, 23,000 marks. The Bache fund of the National Academy of Science in Washington made a contribution to it of $1,400 equalling at that time 5,665 marks. The English publication acknowledges help from the Carnegie Corporation of New York without specifying the amount received. Much of the expense of the German work was in the form of honoraria to the various collaborators, who were paid at the rate of 20 marks per hundred generic names submitted. Whereas the English publication will contain over 225,000 entries, the German one is likely to contain a somewhat smaller number owing

to its completion with the year 1922. This makes the collection of names cost approximately the same in each Nomenclator, if one can compare the value of Marks in 1914 with that of Pounds in 1939.

It is interesting to see at least two Americans singled out for thanks in the British Nomenclator, who were also *Manuskript-Mitarbeiter* in the Prussian Academy work, Professor Nathan Banks and Professor T. D. A. Cockerell.—M. W. Lyon, Jr.

Science in Progress. Edited by George A. Baitsell. Foreword by Harlow Shapley. Yale University Press, New Haven, 1939. xiv + 322 pp., 90 figs., 20 tables. $4.00.

"Science in Progress" is the direct outgrowth of the National Sigma Xi Lectureships held in 1937 and 1938 by eminent men personally responsible for many of the recent advances made in the fields of physics, chemistry, physiology, and biology. Fortunately, the continuation of these lectureships seems to be assured and it is hoped, that public response to the first printed record of them will ensure publication in the future.

In the forword, Harlow Shapley informs the reader that the days when "an encyclopedist.... could gather into fruitful comprehension the facts and theories of all branches of science" are behind us. Yet, not all hope for unification is lost since scientists of the most varied pursuits share "one deep incentive—the satisfaction of intellectual curiosity, the understanding of some part of the world of nature."

Ten essays, covering from twenty to thirty pages each and prepared by such outstanding men as Harold C. Urey, W. M. Stanley, et al., make up the book. The selection favors the biological sciences to some extent, but certainly not to the detriment of the whole work. Other volumes are likely to establish an equilibrium, if that should be desirable at all. That of the seven biological contributions six should be devoted to virus research, vitamins and hormones, metabolism, etc., surprises one less in view of the fact that more progress has been made, on the whole, in these experimental fields than in the corresponding structural branches of biology. Incidentally, this might be construed as a credit to the biologists of yesterday for their sound work were it not true that these fields also have advanced by leaps and bounds, especially paleontology, to mention only one. But we need not despair, for they will find their spokesmen in future volumes.

The reader who can have no complaint regarding the authenticity and reliability of the information incorporated should appreciate the new vistas disclosed by the contributors of our possible scientific outlook in the immediate future. Likewise, he will be grateful for the clear and sound presentation manifest throughout the book which never descends to the level of popular scientific writings now flooding the book market.

This book is, therefore, a most dependable guide through the many forms of modern scientific research and a large number of its most notable achievements, in short, a panorama of "Science in Progress."—Th. Just.

An Introduction to Modern Genetics. By C. H. Waddington. New York, Macmillan Co., 1939. 441 pp., 160 figs., 5 pls. $4.00.

Formerly genetics was mainly concerned with the study of the laws of inheritance. "Modern" genetics is constantly broadening its approach to "inheritance" and thus establishing many points of interest in common with related sciences, notably embryology and phylogeny. It is therefore not surprising, and obviously no apology is needed, that the author, a well known experimental embryologist, should have written the present summary of "modern genetics."

The work is divided into five major parts as follows: 1) Formal Genetics is concerned with the fundamentals of Mendelism, modifications of the chromosome cycle, the behaviour of individual chromosomes, the linear differentiation of individual chromosomes, and the mechanics of the chromosomes; 2) Genetics and Development offers an excellent summary of our knowledge of genes and development, the interactions of genes: the effects, gene controlled processes, the genetic control of pattern, and sex determination, one of the best chapters; 3) Genetics and Evolution treats of the pro-

cesses of evolution, the genetic nature of taxonomic differences, and evolutionary mechanisms; 4) Genetics and Human Affairs reveals a sane approach to and discussion of some of the most disputed problems; and 5) The Nature of the Gene is concluded with the following frank statement "that the exact knowledge at our disposal is so meager that very many alternative hypotheses are still possible as to the nature of the chromosome, and the gene in its different senses." Yet the problem of the constitution of genes remains "one of the most fundamental questions of biochemistry, well worthy of discussion even long before it can be fully answered." Appended are "Laboratory Methods for Class Work on Drosophila" and a Bibliography also usable as an author index. The bibliography (pp. 409-434) functions as an admirable guide through the wealth of available literature, mostly of very recent date.

Although space does not permit detailed discussions of the contents, this reviewer is happy to call attention to the adequate treatment given to the lower plants whose genetic behavior offers many problems not as readily available in higher organisms. This example may suffice to illustrate the inclusiveness of the book and the author's thoroughness in its preparation.

The reader may not find all that he is accustomed to see in other textbooks of genetics but he will be well repaid by the material here included. His outlook will be less one of "formal genetics" but rather one of a broad biological nature. While the book might thus fall short of certain expectations as a text for some courses in genetics, it will assume its rightful place in biological literature as one of the best attempts to bridge the old genetics with its many related biological sciences.—TH. JUST.

PRINCIPLES OF GENETICS. By Edmund W. Sinnott and L. C. Dunn. McGraw-Hill Book Co., New York, 1939. 3.ed., xiv + 408 pp., frontispiece, 147 figs., 32 tables. $3.50.

Of the biological sciences genetics is probably progressing more rapidly than any other branch of knowledge, making it imperative that new editions of standard textbooks be prepared at regular intervals. To meet this demand the authors have thoroughly revised the "Principles" by eliminating parts of the former edition in favor of more recent work and by the addition of much new material. The many problems now appended to each chapter should prove a splendid means for the student to test his understanding of genetics.

The classic experimental ground of genetics, Mendel's garden in Brünn, as figured on the frontispiece of the former edition, has been replaced by a new detachable one showing Bridge's "maps of the chromosomes of the salivary gland cells of *Drosophila melanogaster*" (Jour. Hered. 1936). This change in frontispiece bespeaks well the new era in genetics.

While the authors do not profess to have exhausted the subject, they have succeeded in revising their book so well that it presents an excellent cross-section of well-founded genetical facts and of the most plausible hypotheses based on these.—TH. JUST.

ANIMAL ECOLOGY. By A. S. Pearse. McGraw-Hill Book Co., New York, 1939. 2. ed. xii + 642 pp., 133 figs. $5.50.

Animal ecology may not be among the oldest branches of biological knowledge, but it is easily among the largest. A survey of the field, then, must of necessity be extensive to warrant any claim of adequate treatment. Thus in revising the first edition, the author made such drastic changes as combining certain chapters, adding seven new chapters and more than one hundred new illustrations, and finally adopting, on the whole, "a more logical arrangement." Because of its almost encyclopedic character, the book discloses at once the present status of our knowledge of animal ecology and the many lacunae in it awaiting intensive future study.

The bibliography (pp. 569-633) is for most part a reliable guide through the laby-

rinth of ecological literature. It is regrettable, however, that certain citations are partly erroneous and that recent literature on cave animals, for example, has not been included. But in view of the many other good features of the book, such minor criticisms are obviously negligible.

The book remains a leading text in the field and, as such, an important factor in the future development of animal ecology.—TH. JUST.

A LABORATORY INTRODUCTION TO ANIMAL ECOLOGY AND TAXONOMY. A Laboratory Guide with Keys Prepared with Particular Reference to Fresh-Water and Terrestrial Habitats of the Deciduous Forest Region in North America. By Orlando Park, W. C. Allee, and V. E. Shelford. University of Chicago Press, Chicago, 1939. x + 272 pp., 17 pls. $2.00.

According to the Foreword "this book represents the work of three academic generations of teaching ecologists." In preparing the present edition Dr. Park did not confine himself to a revision of the "Synoptic Keys" but took the opportunity to include "a series of exercises on the more common field animals and to co-ordinate the keys and exercises with a general approach to natural history from the ecological point of view." A number of instructive plates, mostly original, were also added. Thus, the book opens with an "Introductory Discussion Concerning the Interrelationship of Animals with their Environments" (pp. 1-22), which is followed by the "Exercises" (pp. 25-126) and "Synoptic Keys" (pp. 127-194). Appended are a "Glossary of Technical Terms Used in the Keys" (pp. 197-210), the carefully selected Bibliography (pp. 213-257) and Indexes.

The laboratory character of the book is emphasized by its modern spiral binding the suitability of which will have to be determined with continued use. Otherwise the physical make-up is of the well-known style and quality of the University of Chicago Press.

One addition, at least, might be considered as far as the bibliography is concerned, namely "The Fresh-Water Algae of the United States" by G. M. Smith (1933). This American work should prove more useful in the identification of pigmented flagellates than "A Treatise on the British Fresh-Water Algae" by West and Fritsch (1928).

The usefulness of the book in the past combined with the additions and changes now incorporated make it an indispensable aid in the study of animal ecology and taxonomy.—TH. JUST.

THE WORLD OF INSECTS. By Carl D. Duncan and Gayle Pickwell. McGraw-Hill Book Co., New York, 1939. ix + 409 pp., frontispiece (fig. 1 colored) + 193 figs. $3.50.

If the insects were not the most numerous group of animals, one might be tempted to say that the available popular books concerning them rival their heroes in number. And, like the insects themselves, they vary from "injurious" to truly "beneficial" in their effects. With such a collection on hand, any new venture must distinguish itself notably to be regarded as a real addition. This can well be said of the present book despite its decided emotional appeal to "nature lover, nature student, or nature teacher."

The greater part of the book is concerned with the many and varied aspects of insect life, e.g., "How Insects Grow Up," whereas the rest deals with "The Value of Insects," etc., methods of collecting, rearing, and preserving them. The many fine illustrations, which are largely original, add materially to the value of the book. As a result, "The World of Insects" seems to do justice to the authors' statement "Insects! One is inclined to speak of them only in superlatives."—TH. JUST.

FIELD GUIDE TO LOWER AQUARIUM ANIMALS. By Edward T. Boardman. Cranbrook Institute of Science Bulletin no. 16, Bloomfield Hills, Michigan, 1939. 186 pp., 51 figs. Paper cover $1.00, cloth $1.50.

Although the author tells us that "this guide is intended for the use of people who are not afraid of getting their feet wet," it is difficult to see how this virtue alone would necessarily interest them in the lower animal life of our fresh-waters. Actually, the book was prepared for amateur naturalists, aquarium fans, and fishermen who have so far "failed to take full advantage of the huge store of bait animals which are to be found in our various lakes and streams."

The invertebrates being too numerous for complete treatment, a suitable selection of the more common forms was made by the author. The discussion of the individual species, a number of which is clearly illustrated, is simple and free of technical terms, but always informative. A bibliography, a glossary, and an index conclude the book.

All groups from the Protozoa to the Molluscs cover less than a third of the book, whereas the Arthropods, mainly insects, occupy more than a hundred pages. This allotment of space is in keeping with the great importance of the insects in the general life cycle.

Occasionally, the author transgresses the popular level by suggesting the need of work to obtain information not available at present, e.g., on page 139 regarding the food habits of the true crane flies. Thus the book proves of value not only to those for whom it was originally prepared but also to others seriously concerned with the investigation of the life of inland waters. Besides, the book reveals the great interest that our American fauna commands by comparison with the tropical fauna so dear to many aquarium fanciers.—TH. JUST.

THE GEESE FLY HIGH. By Florence Page Jaques, illustrated by Francis Lee Jacques. The University of Minnesota Press, Minneapolis, 1939. Pages 1-102. Including 40 illustrations, many of them occupying a full page. Price $3.00.

This is a popular account of a trip in which geese and ducks were intensively studied, particularly by Lee Jaques. The illustrations are excellent examples of black and white pen and ink work, beautifully reproduced. Brief mention is made of the duck ranges in the north central United States. Tenting in the swamps of Arkansas is vividly described. The human and some of the vertebrate life in the marshes of the southern coast of Louisiana especially in the Rainey Wildlife Refuge is interestingly portrayed. The author writes well, and her pen pictures of swamp and marsh life are as good as her husband's drawings. She makes no claim for the book as a piece of scientific writing, although there is every indication that her statements and descriptions are accurate. It can be highly recommended for light scientific reading and as a handsomely illustrated gift book for those who are interested in our native waterfowl.

The next to the last paragraph in the book is well worth quoting: "Here Mr. White and another guide, both of whom had hunted on these Louisiana marshes for thirty years, followed us, after their supper, and in the firelight they told us tales of the old days when ducks and geese swarmed here by the millions and the great cranes danced fantastically on the marsh grass."

In spite of all that has been done to preserve ducks and geese in order that they may be shot for sport, this statement is a frank acknowledgment of their continually diminishing numbers. Mr. White and the other guide could have talked in equally glowing terms about the former Kankakee Marsh, Indiana, apparently now ruined beyond recall.—M. W. LYON, JR.

NEUE ZIELE DER BOTANIK. Von Karl Suessenguth. J. F. Lehmanns Verlag, München/Berlin, 1938. 160 pp., 7 figs. Paper RM 6.00, cloth RM 7.20.

This collection of essays is not so much concerned with the past as it is with the future of botany. It is the author's belief that many problems need re-examination, mainly through the introduction of new viewpoints, in this case his own. The reader will be astounded by the versatility of the author who is actively contributing to our knowledge of various fields of botany such as taxonomy, morphology, and physiology.

The book is divided into two parts, part one is systematic and plant geographic in content and of main interest here, whereas part two is physiological and composed of twenty-two of the twenty-five essays included. The contributions of part one deal with problems of phylogenetic relationship among the Angiosperms, the origin and development of areas occupied by families of flowering plants, and are concluded with scathing comments concerning the theory of continental drift. Extensive discussions are found here regarding the position of the Monochlamydeae, the evaluation of ancestral and recently acquired characteristics, the importance of alternation of generations, the occurrence of nearly or entirely choripetalous corollas among the Sympetalae, the problem of monotopic and monophyletic vs. polytopic and polyphyletic origins of plant groups, and finally regarding the inadequacy of the theory of continental drift as shown by the facts of floral history.

The physiological part occupies two-thirds of the book, is more varied in content, but equally thought provoking. A concluding essay describes the present status of biological research and is filled with caustic remarks and critical observations. The author pleads strongly for the recognition of sound theoretical work beyond the experimental acquisition of new data so popular at present and for the elimination of scientific dogmatism which impairs so frequently the possibility of real advance.—TH. JUST.

GERMAN-ENGLISH SCIENCE DICTIONARY—For Students in the Agricultural, Biological and Physical Sciences. By Louis De Vries. McGraw-Hill Book Co., New York, 1939. x + 473 pp., 5 x 7, flexible binding. $3.00.

With the growth of any science its vocabulary increases correspondingly. As a result available dictionaries are in need of revision or a demand for new ones arises. The author's teaching experience at Iowa State College over a long period of years acquainted him with the needs of advanced students, especially with the great necessity of providing an integrated dictionary for them. In close cooperation with members of the graduate faculty of his college, he undertook the tremendous task of preparing a dictionary containing the vocabulary of the many sciences concerned.

Some 48,000 entries were chosen without claim of completeness. Obviously, not all entries are scientific since verb forms etc., are included for the student's benefit. The selection of the entries appears to be, on the whole, a careful one though a few terms could have been added with profit, e.g., *Plasten*, *Blaualgen* etc. Not all equivalents are correct or complete, viz., *Kernhaut* is also nuclear membrane and *Wanderversammlung* might best be rendered as foray. There are few real misprints, but sometimes the wrong singular or plural form is given, e.g., the German word is given in the singular and the English equivalent in plural. It is hoped that such minor discrepancies will be adjusted in a new edition which the book is destined to undergo.

The inclusion of a list of reference works is very commendable, but not the omission of bibliographic data concerning them. The classification of some titles is surprising, certainly in the case of such works as the large "Handwörterbuch der Naturwissenschaften," Schneider's "Illustriertes Handwörterbuch der Botanik," and Ziegler's "Zoologisches Wörterbuch" which hardly qualify as mere "Glossaries." Perhaps it might be worthwhile to consider the addition of such reference works as Van Wijk's "Dictionary of Plant-Names" to assist the student in locating proper source material.

All of us who have had experience in teaching scientific German will gladly recommend this useful book to our students who, in turn, will be grateful to the author for his labor and the care with which he has prepared "the first dictionary of its kind."

—TH. JUST.

AN ILLUSTRATED MANUAL OF CALIFORNIA SHRUBS. By Howard E. McMinn. J. W. Stacey Inc., San Francisco, 1939. xi + 689 pp., colored frontispiece and 775 figs., $5.00.

According to the publisher's jacket, "it was inevitable that a complete book on the shrubs of California would appear and equally inescapable was the fact that the man to write it was Howard McMinn." Although "planned primarily for the use of the general public" professional botanists will find this manual an indispensible aid.

The richness of the flora of California is shown by the fact that about 800 species and varieties of native shrubs (exclusive of the Cactus family) as well as fourteen naturalized species are included in the book. For each of these are given adequate descriptive matter, citations, distribution, and interesting information regarding habitat, requirements and behavior in cultivation. These data were obtained by the author over a period of twenty years through countless field observations and systematic transplant studies. The inclusion, moreover, of a general introduction to botanical terminology with illustrations, of a glossary of botanical terms, and finally of an "Index to Names of Species and Varieties of California Shrubs" by Daniel Dewey will be of real assistance to those not so familiar with the intricacies of systematic botany. A list of all nomenclatorial changes, in the main new combinations, a bibliography, a useful chapter by Fred H. Schumacher on the "Use of California Shrubs in the Garden Design" (pp. 649-674), and an index to plant names conclude the book. The majority of the excellent illustrations was drawn by several artists whose intelligent cooperation is acknowledged by the author.

The exquisite workmanship displayed in the production of this manual is a credit to the publisher and the author's labors in the preparation of it.—TH. JUST.

THE LEGUMINOUS PLANTS OF WISCONSIN. The Taxonomy, Ecology and Distribution of the Leguminosae Growing in the State without Culivation. By Norman C. Fassett with Drawings by Richard I. Evans and a Study of Epidermal Outgrowths by Catherine Mose. The University of Wisconsin Press, Madison, 1939. xiii + 157 pp., 24 pls., 60 figs., 96 maps. $3.00.

The Leguminosae comprise a large and admittedly difficult group of flowering plants. Hence a detailed treatment of its representatives in a given area, even though circumscribed by state boundaries, is most welcome. The book contains adequate treatment of nearly one hundred species and varieties, mostly of wide American distribution, thus not limiting its usability to Wisconsin. Keys based on vegetative characters, on fruits, on seeds, as well as that by Miss Mose on the epidermal outgrowths (pp. 133-136), and used with their respective illustrations, should enable the collector to identify his material even from some fragments. The author, moreover, was ably assisted by Dr. Evans who prepared the splendid drawings reproduced as plates. The latter, together with the many fine photographs, impart considerable value to the book the workmanship of which is a real credit to the University of Wisconsin Press.

American botanists would be very fortunate, indeed, if more books of this type dealing with other difficult families were available at this time.—TH. JUST.

SUPPLEMENT TO ROOT NODULE BACTERIA AND LEGUMINOUS PLANTS. By E. B. Fred, I. L. Baldwin, and E. McCoy. The University of Wisconsin Press. Madison. 1939. 40 pp. $0.50.

Since the publication of *Root Nodule Bacteria and Leguminous Plants* in 1932 many important investigations dealing with the characteristics of the leguminous plants and of the bacteria associated with them have been reported. Because of the great importance of the leguminous problem and the scientific interest in it the authors have felt it advisable to publish the available references to the recent work in this field.

They have not attempted to interpret the results but simply have listed the 486 papers published from 1932 to 1938.

In addition to the citations to literature the supplement includes an author index and a list of the scientific names of all the plants mentioned in the original publication.

The monograph on the Root Nodule Bacteria and Leguminous Plants which is recognized as a classic in the field of soil microbiology is now available with a supplement making it complete and up to date.—N. L. NOECKER.

EDIBLE WILD PLANTS. By Oliver Perry Medsger. Macmillan Co., New York, 1939. xv + 323 pp., 80 figs., 19 pls., $3.50.

Though once much more important, edible wild plants still retain their lure for many, as is evident from the folklore surrounding them, the many names in use for them and the numerous known recipes for their preparation. It is this sort of information regarding some 150 important species as well as many minor and lesser known groups, which the author collected painstakingly during his long life and which he recorded in the present volume. Added as spices to this interesting text are many poetic quotations inspired by these plants, whose identification is greately facilitated by the illustrations and the very useful "finding index" (pp. 235-304) which gives common and scientific names, characteristics, range, season, and page reference in the book. Apart from its usefulness as a convenient reference work it will be to many, as Ernest Thompson Seton puts it in his preface, "the book I dreamed of—the key to the woods."

TH. JUST.

POISONOUS PLANTS OF THE UNITED STATES. By Walter Conrad Muenscher. Macmillan, New York, 1939. xvii + 266 pp., 75 figs. $3.50.

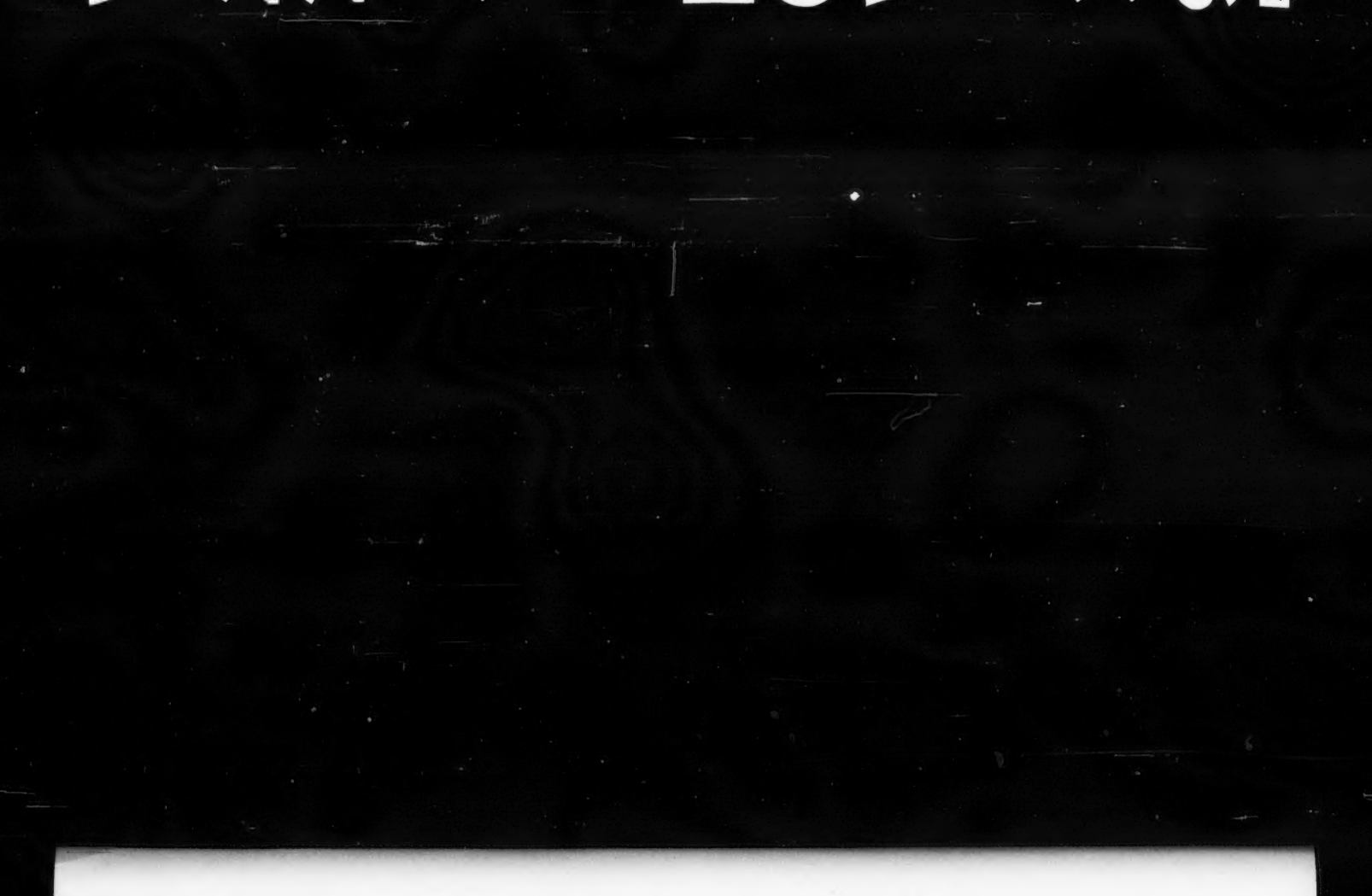
The study of poisonous plants is far from being a purely academic concern, as is shown by the fact that the recent investigations pertaining to them and summarized by the author in the present volume were carried out by scientists of the U. S. Department of Agriculture or the state experiment stations. Future research, moreover, is likely to increase the number of plants known to possess poisonous properties beyond the 400 species of vascular plants included here.

Whereas part one (pp. 1-18) is general in character and contains, e.g., lists of plants causing dermatitis, part two (pp. 19-239) constitutes the bulk of the book and is systematic throughout. The account of each species includes brief descriptions, geographic distribution, habitat, data concerning the poisonous constituents and the effects of poisoning as well as the treatment of it, and, in many cases, illustrations. The appended bibliography (pp. 241-252) lists mainly recent titles.

The book can be recommended for ready reference use and as an interesting addition to our general knowledge of American plants.—TH. JUST.

TREES OF THE SOUTH. By Charlotte Hilton Green. The University of North Carolina Press, Chapel Hill, 1939. xiv + 551 pp., profusely illustrated. $2.50.

This book was written to "arouse a love, an understanding, and an appreciation of trees, for their beauty, their wonder, and their use." Accordingly the author writes about trees in a very personal way by the frequent use of their Indian names in preference to their scientific ones and by the inclusion of numerous poems and anecdotes. Yet scientific accuracy is insured by the assistance received from competent botanists. The appeal to the "tree-lover" is greatly enhanced by the large number of fine photographs showing either habits or structural details. Books of this kind reach a small but constantly growing group of readers which represents a significant force in accomplishing the aims of modern conservation.—TH. JUST.



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